PERCEPT

5Labs
Elevating Human Potential Through Technology

# Indoor Navigation System

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massDOT Massachusetts Department of Transportation
MBTA

# Outline

- Introduction
- Demonstration
- System Overview
- Usability Study
- Conclusion

# Outline

- **Introduction**
- Demonstration
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PERCEPT

# Introduction

- Enables blind users to independently navigate in unfamiliar indoor environments
- Percept is an **orientation aid** used in conjunction with mobility aids
- Co-Designed with Certified Orientation and Mobility Specialists (COMS) from Massachusetts Commission for the Blind
- Successful trials conducted at UMASS and MBTA subway station with over 60 blind and visually impaired human subjects
- Featured several times in:

The Boston Globe

cover story

INDEPENDENCE IN AN APP

INDOOR NAVIGATION SYSTEM WILL OPEN NEW DOORS FOR THE VISUALLY IMPAIRED AT BOSTON-AREA MBTA STATIONS

Navigating inside an MBTA station

- Latest Article

# National Federation of the Blind (NFB)

- Finalists at the NFB Indoor Navigation Summit (December 2015).

NATIONAL FEDERATION
OF THE BLIND

- Anil Lewis Executive Director NFB:

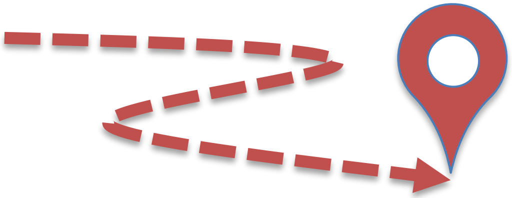
**“The PERCEPT System is the only indoor navigation system we have identified that provides detailed point-to-point descriptive navigation instructions within an indoor venue. “**

# Advantages

**Deployed and Successfully Tested**

Buildings & Subway Stations
with over 60 BVI Trials

**True Wayfinding**



Using detailed automated
navigation instructions,
*You are never lost*

**Pre-Journey Navigation**

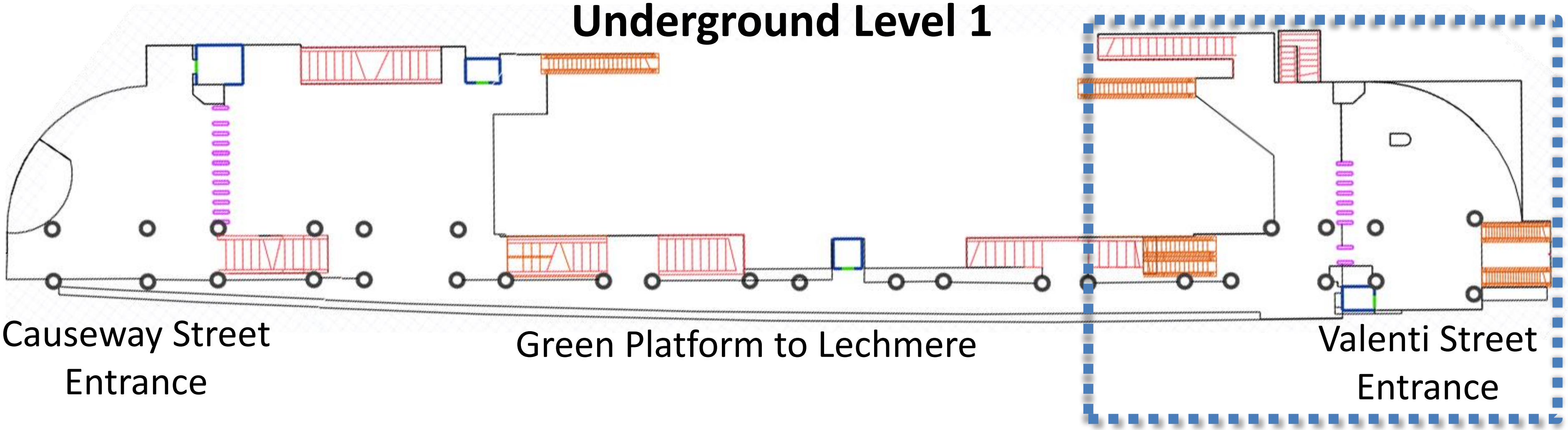
Build mental map of environment
before stepping foot in it

# Outline

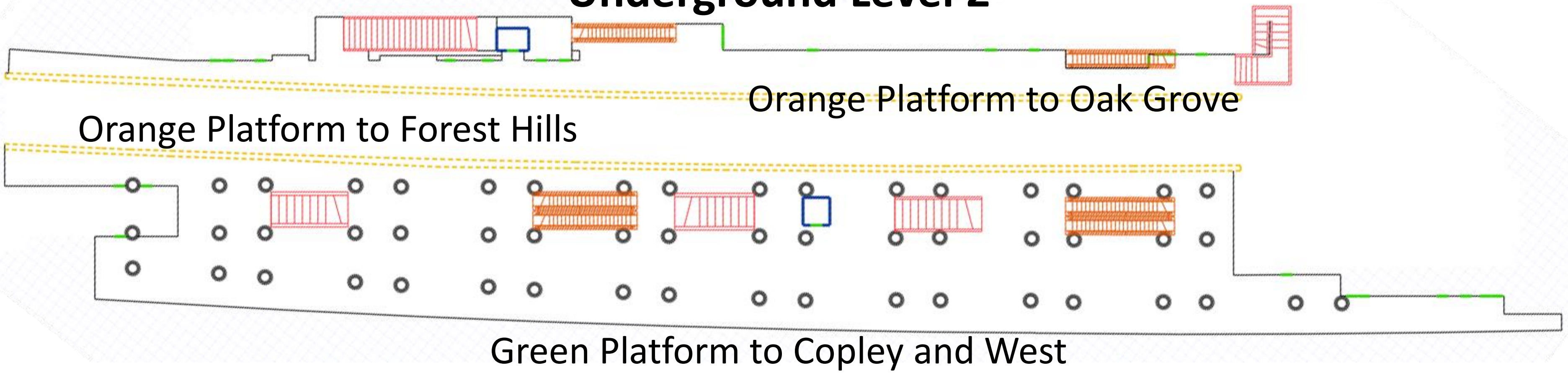
- Introduction
- **Demonstration**
- System Overview
- Usability Study
- Conclusion

# Demonstration: North Station Subway Overview

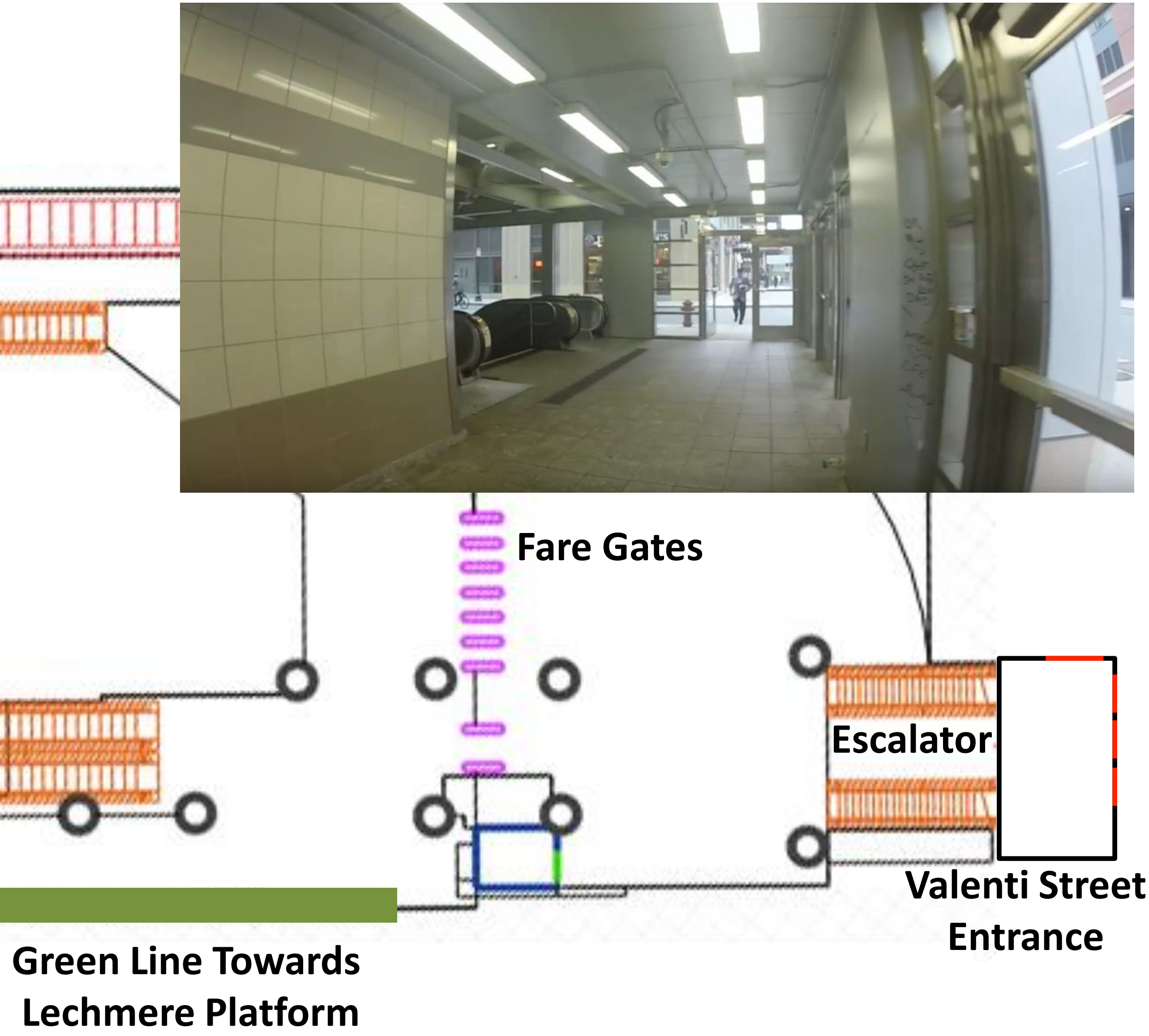
## Underground Level 1

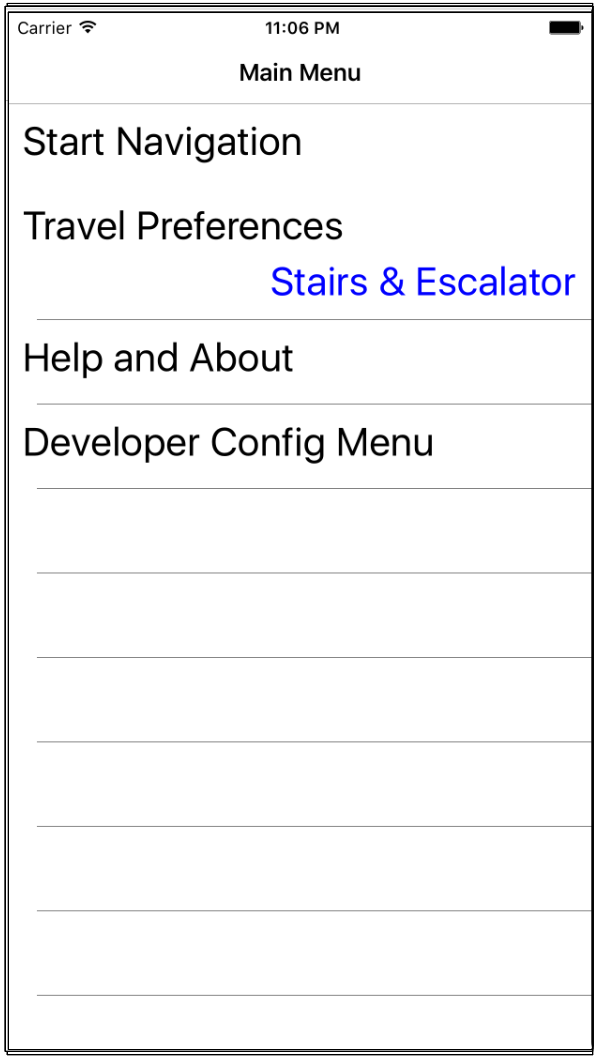

Causeway Street Entrance
Green Platform to Lechmere
Valenti Street Entrance

## Underground Level 2

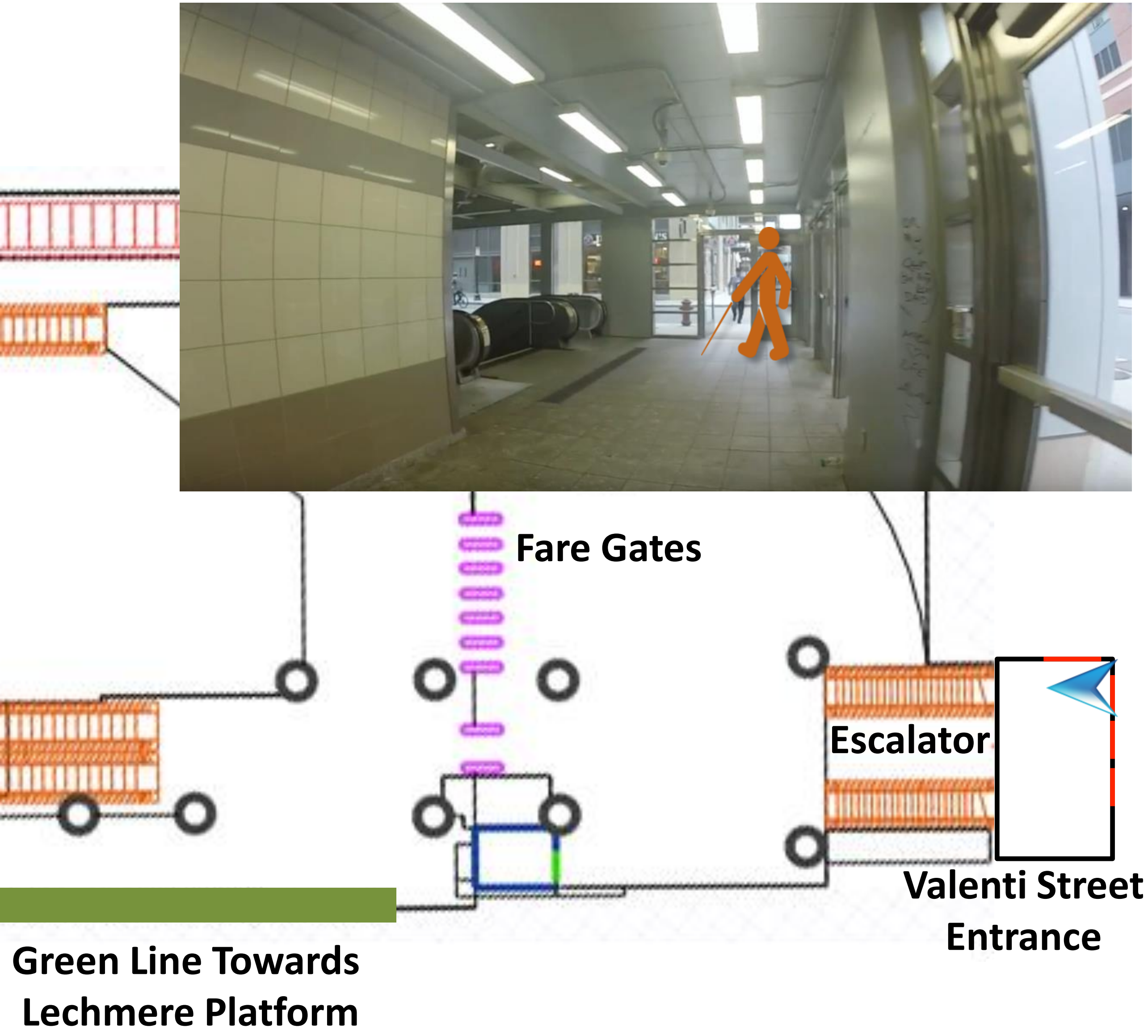

Orange Platform to Oak Grove
Orange Platform to Forest Hills
Green Platform to Copley and West

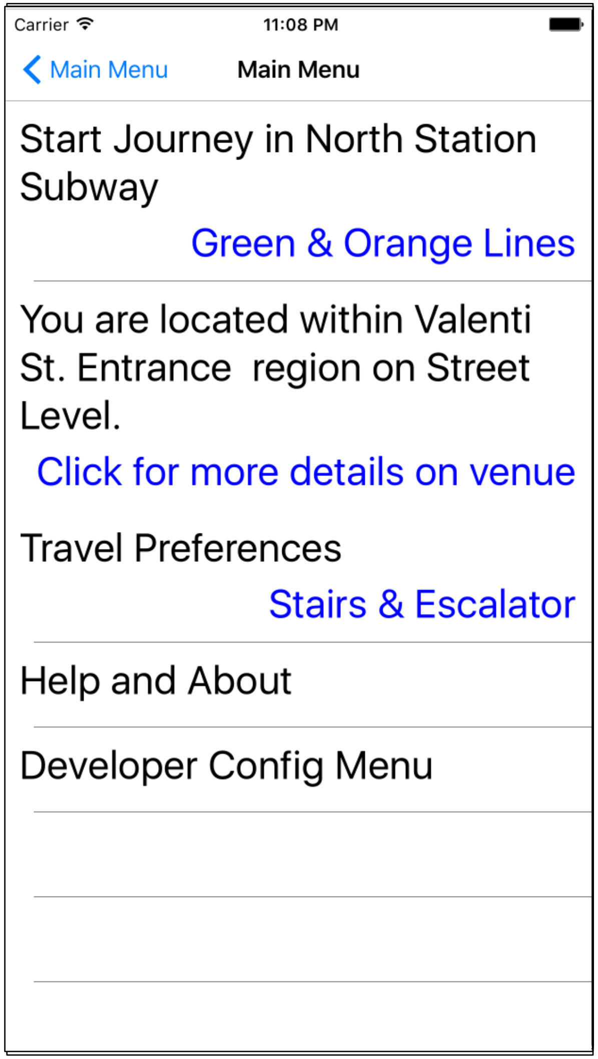
# Demonstration


Fare Gates
Escalator
Valenti Street Entrance
Green Line Towards Lechmere Platform


Carrier
11:06 PM
Main Menu
Start Navigation
Travel Preferences
Stairs & Escalator
Help and About
Developer Config Menu

# Demonstration


Fare Gates
Escalator
Valenti Street Entrance
Green Line Towards Lechmere Platform


Carrier
11:08 PM
Main Menu

**Main Menu**

Start Journey in North Station Subway

Green & Orange Lines

You are located within Valenti St. Entrance region on Street Level.

Click for more details on venue

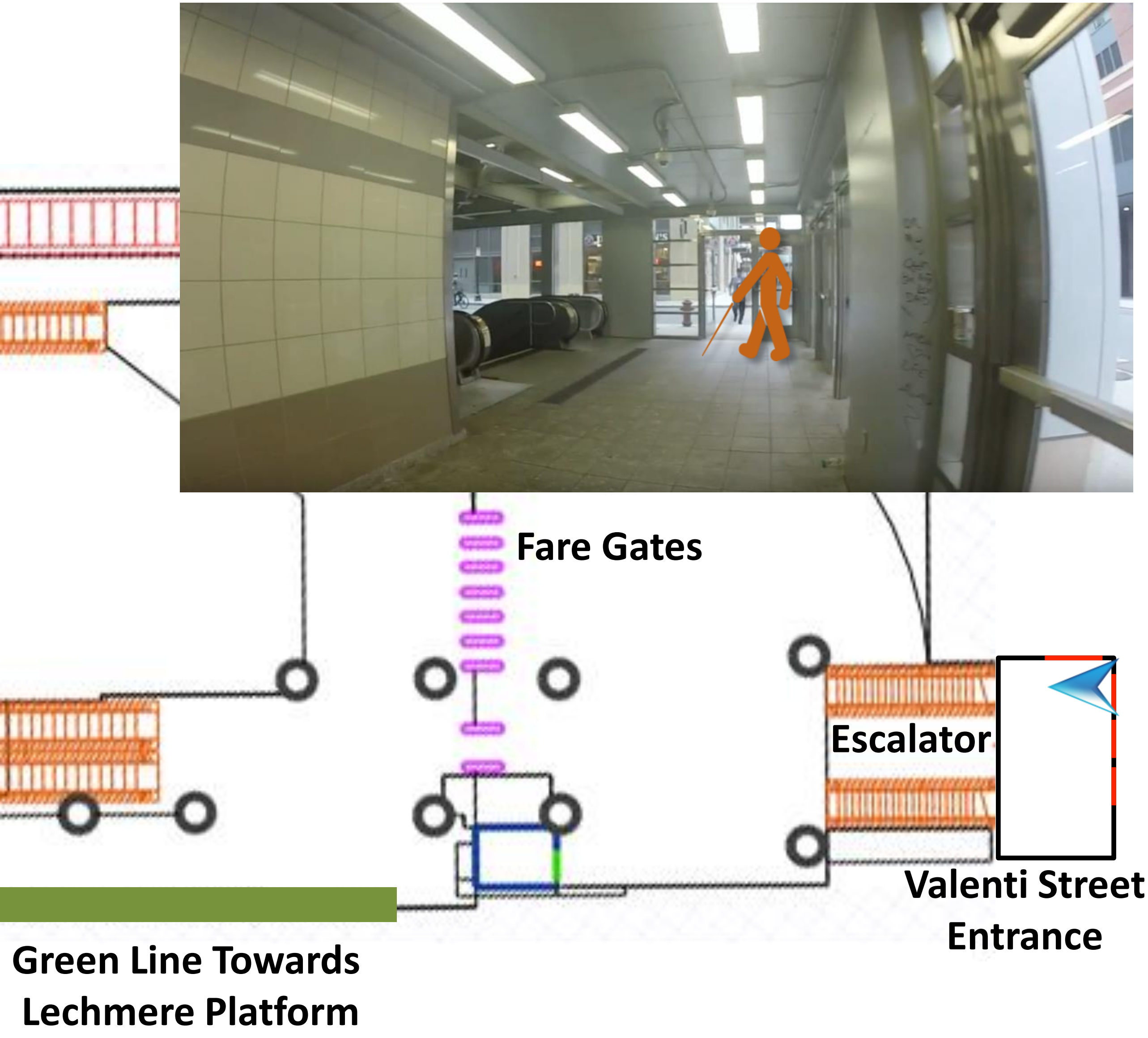
Travel Preferences

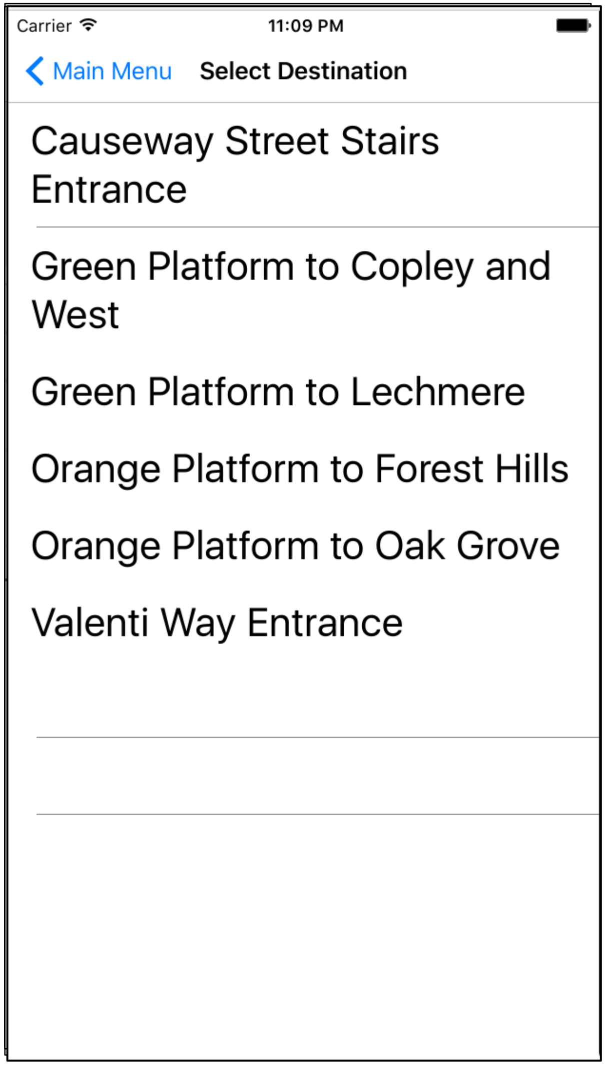
Stairs & Escalator

Help and About

Developer Config Menu

# Demonstration


Fare Gates
Escalator
Valenti Street Entrance
Green Line Towards Lechmere Platform


Carrier
11:09 PM
Main Menu
Select Destination

Causeway Street Stairs Entrance

Green Platform to Copley and West

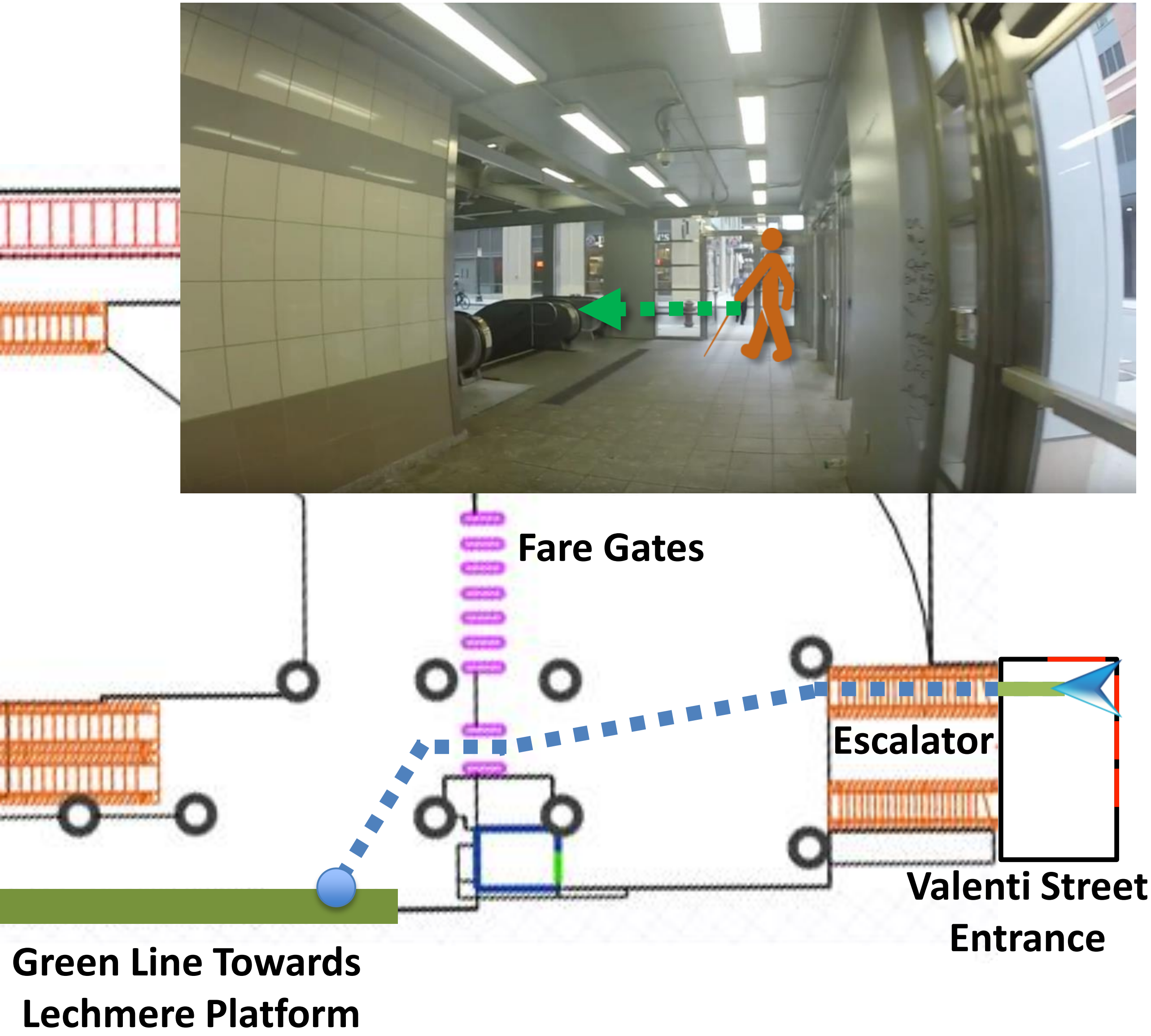
Green Platform to Lechmere

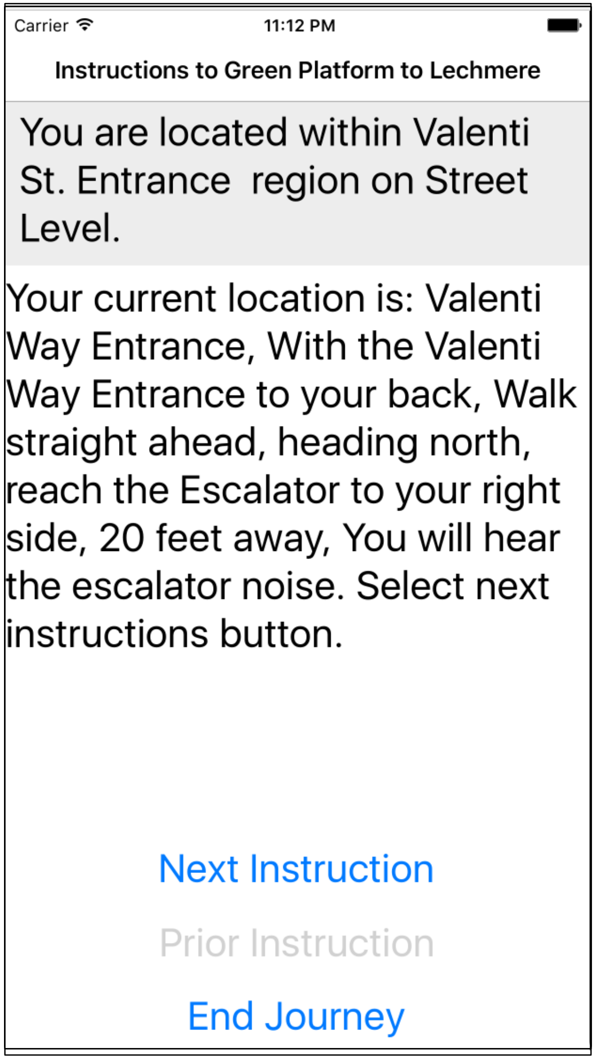
Orange Platform to Forest Hills

Orange Platform to Oak Grove

Valenti Way Entrance

# Demonstration


Fare Gates
Escalator
Valenti Street Entrance
Green Line Towards Lechmere Platform


Carrier
11:12 PM

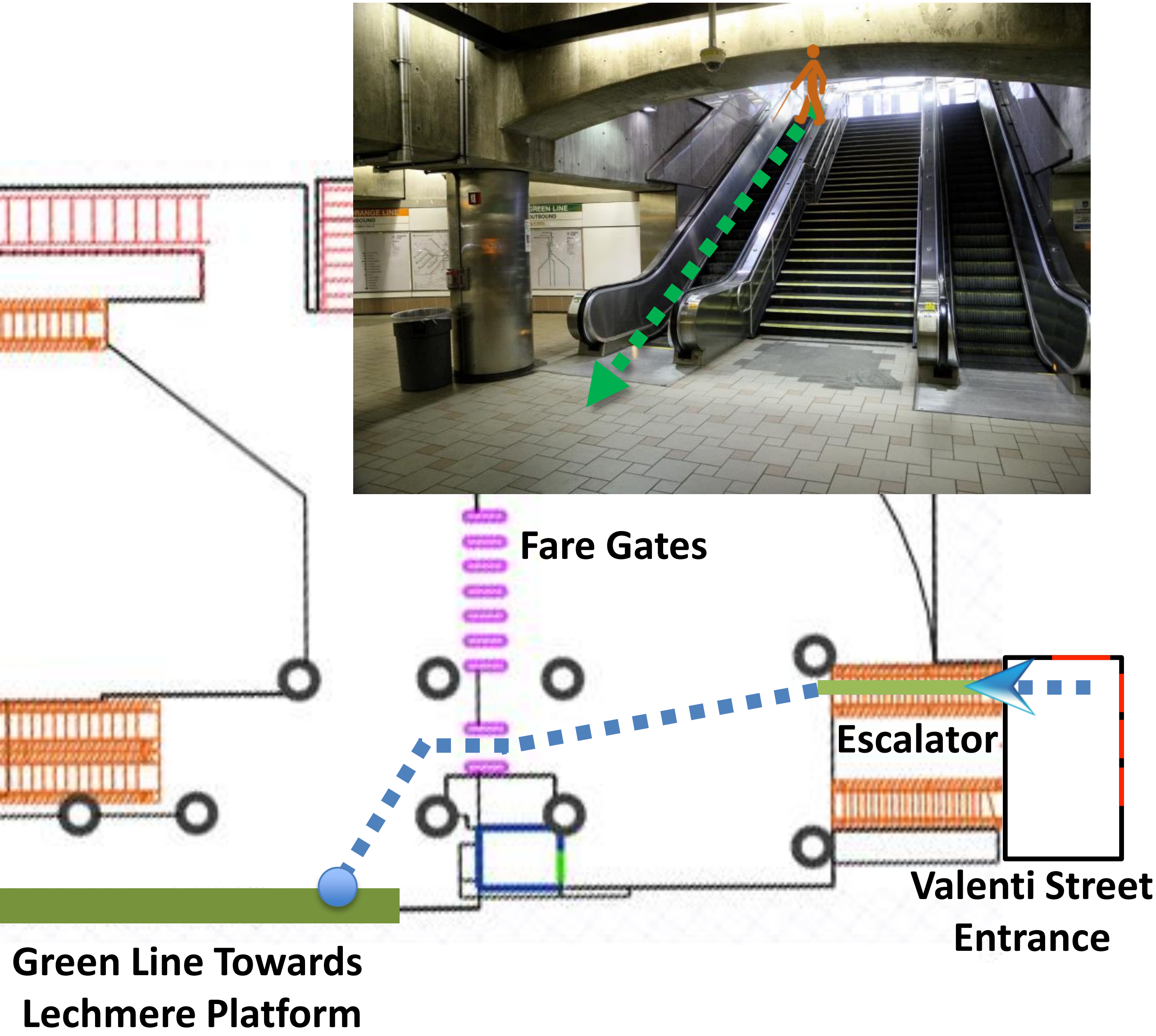
**Instructions to Green Platform to Lechmere**

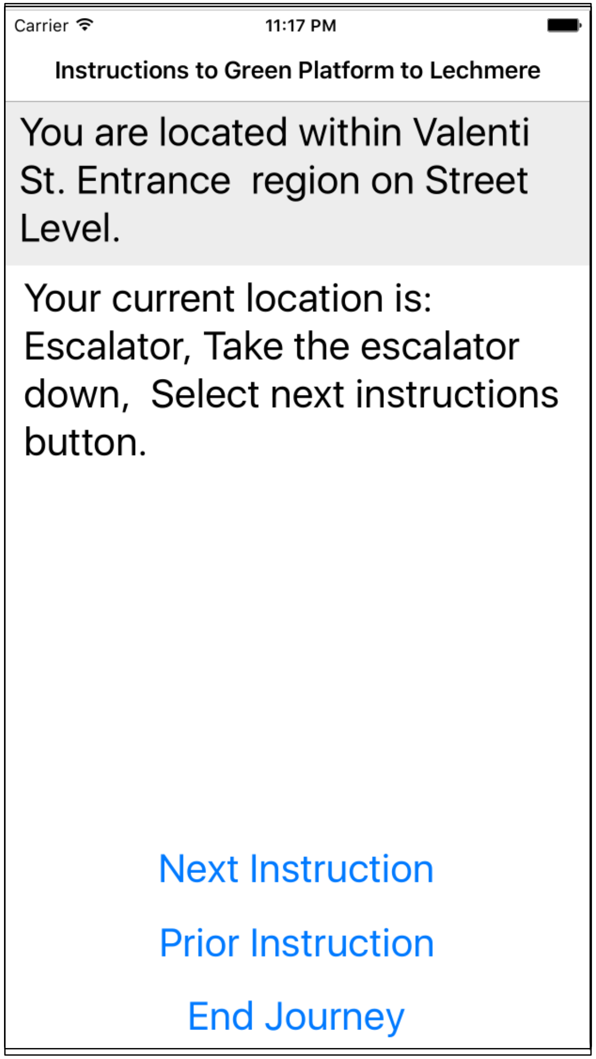
You are located within Valenti St. Entrance region on Street Level.

Your current location is: Valenti Way Entrance, With the Valenti Way Entrance to your back, Walk straight ahead, heading north, reach the Escalator to your right side, 20 feet away, You will hear the escalator noise. Select next instructions button.

Next Instruction
Prior Instruction
End Journey

# Demonstration


Fare Gates
Escalator
Valenti Street Entrance
Green Line Towards Lechmere Platform


Carrier
11:17 PM

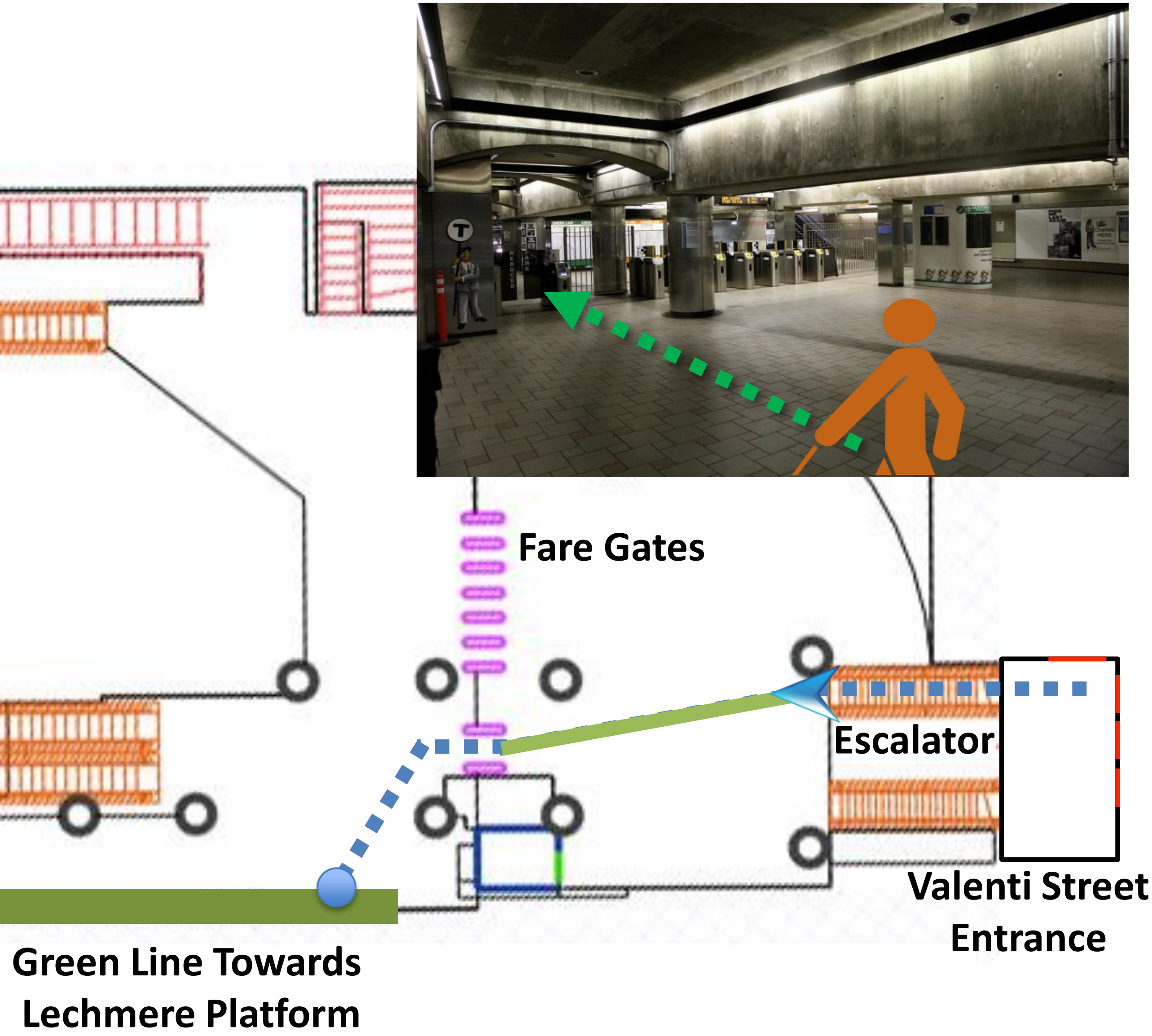
**Instructions to Green Platform to Lechmere**

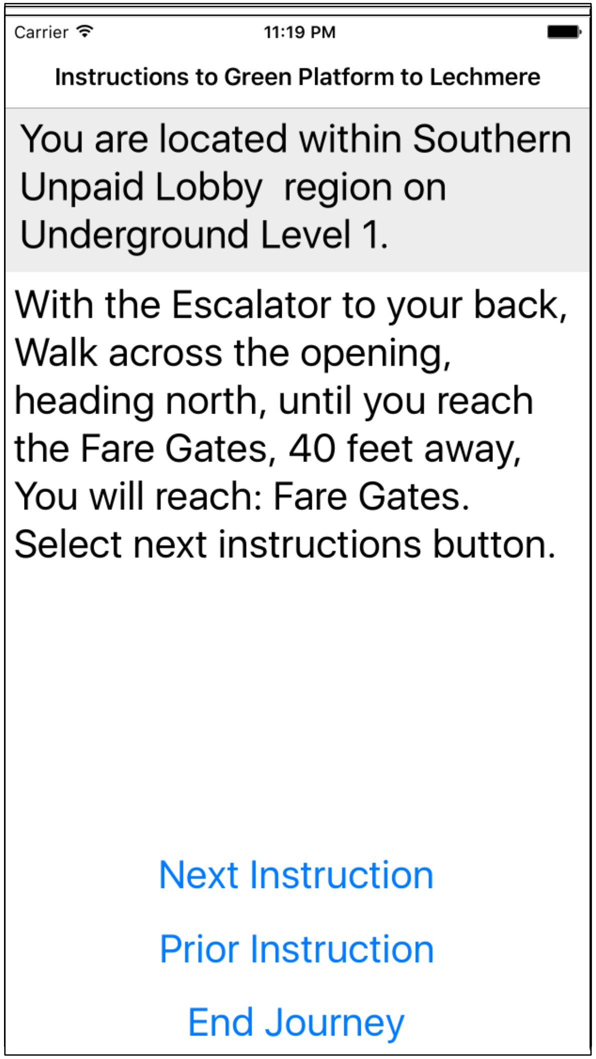
You are located within Valenti St. Entrance region on Street Level.

Your current location is: Escalator, Take the escalator down, Select next instructions button.

Next Instruction
Prior Instruction
End Journey

# Demonstration


Fare Gates
Escalator
Valenti Street Entrance
Green Line Towards Lechmere Platform


Carrier
11:19 PM

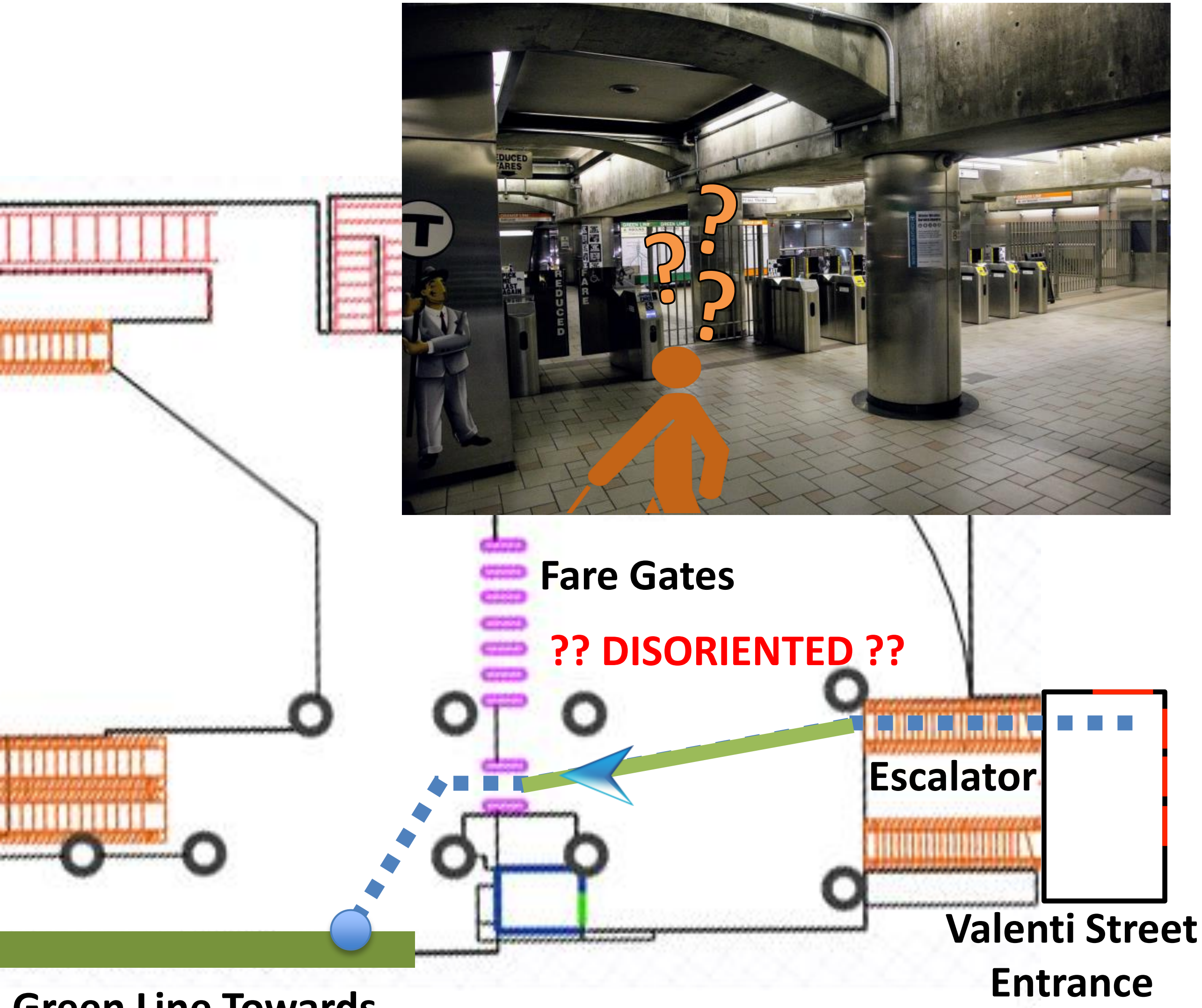
**Instructions to Green Platform to Lechmere**

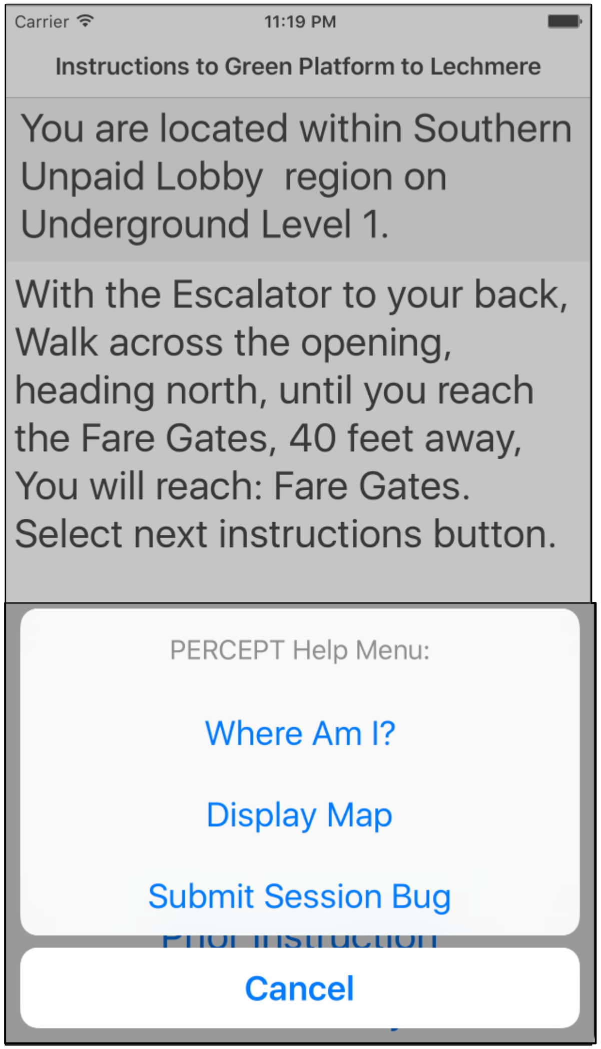
You are located within Southern Unpaid Lobby region on Underground Level 1.

With the Escalator to your back, Walk across the opening, heading north, until you reach the Fare Gates, 40 feet away, You will reach: Fare Gates. Select next instructions button.

Next Instruction
Prior Instruction
End Journey

# Demonstration


Fare Gates
?? DISORIENTED ??
Escalator
Valenti Street Entrance
Green Line Towards Lechmere Platform


Carrier
11:19 PM

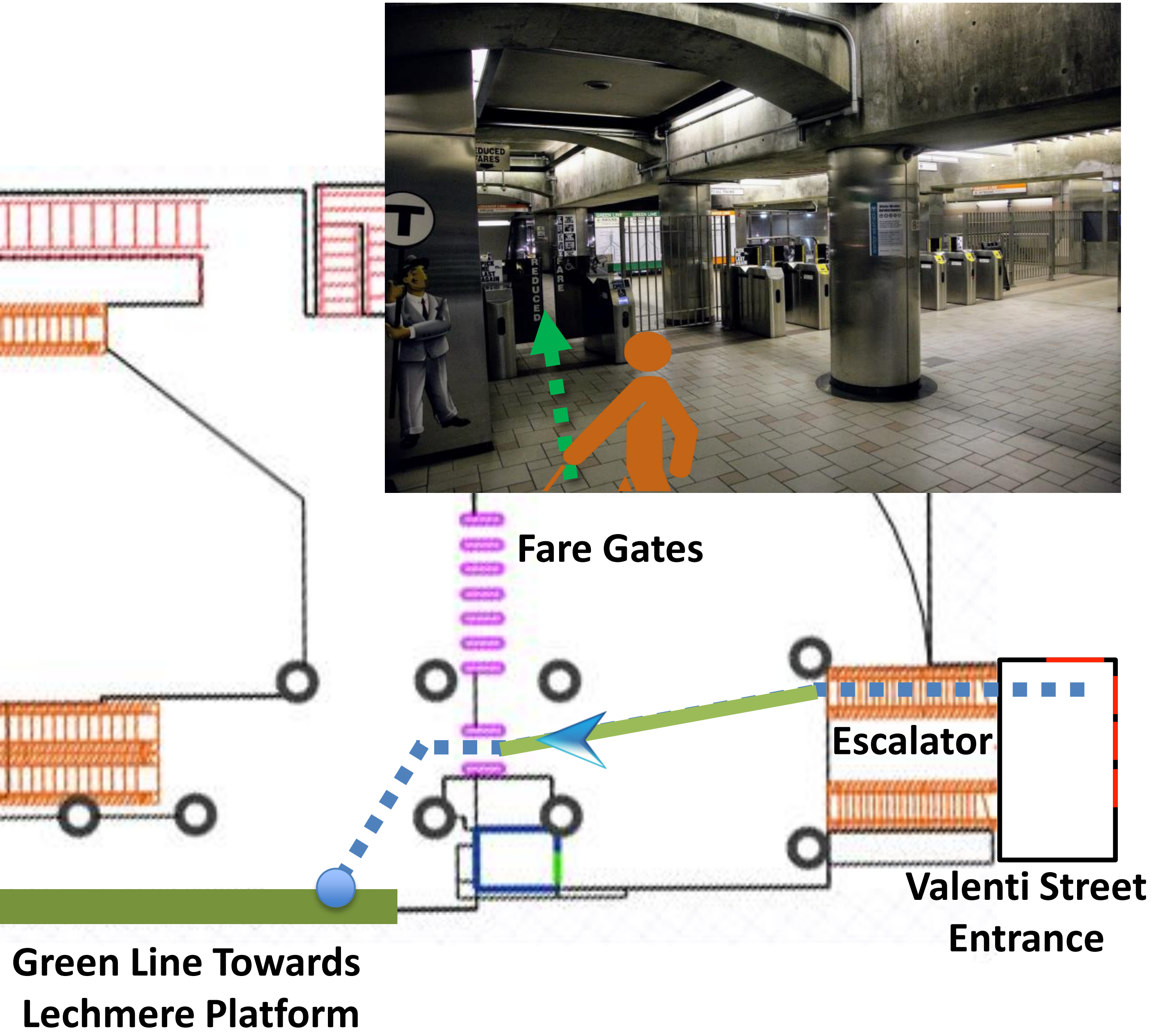
Instructions to Green Platform to Lechmere

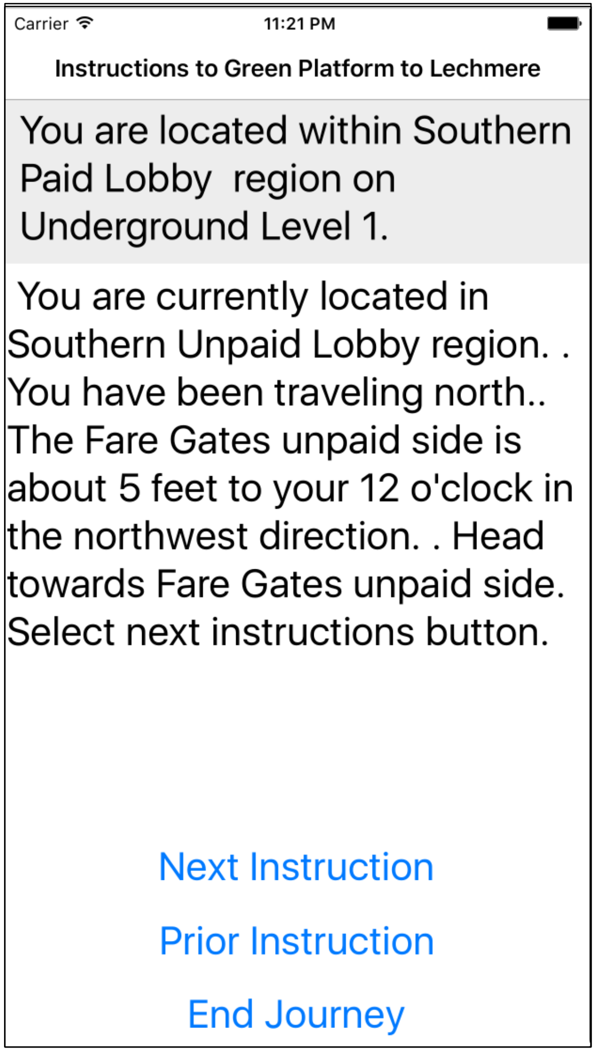
You are located within Southern Unpaid Lobby region on Underground Level 1.

With the Escalator to your back, Walk across the opening, heading north, until you reach the Fare Gates, 40 feet away, You will reach: Fare Gates. Select next instructions button.

PERCEPT Help Menu:
Where Am I?
Display Map
Submit Session Bug
Cancel

# Demonstration


Fare Gates
Escalator
Valenti Street Entrance
Green Line Towards Lechmere Platform


Carrier
11:21 PM

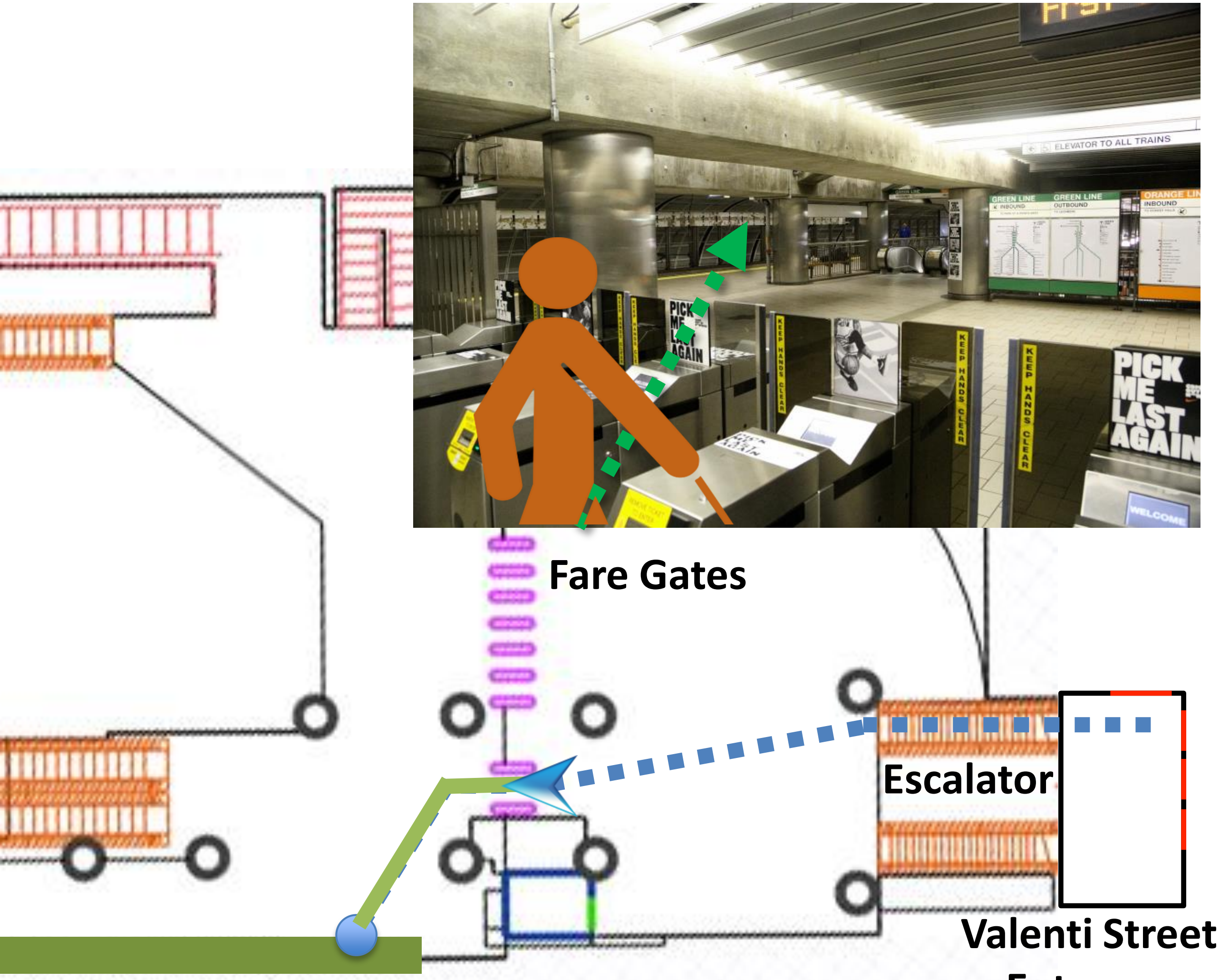
**Instructions to Green Platform to Lechmere**

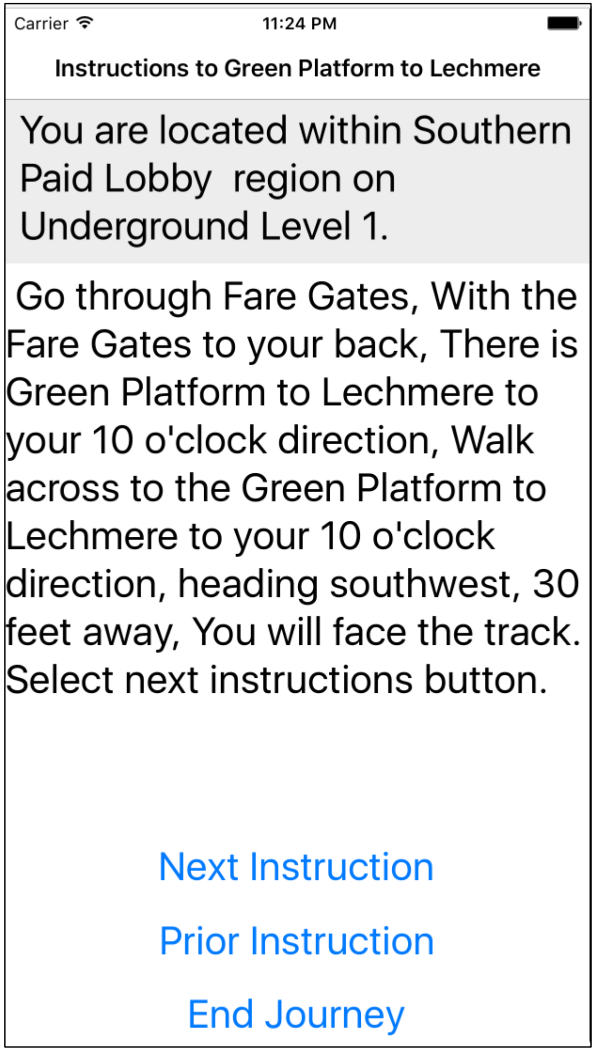
You are located within Southern Paid Lobby region on Underground Level 1.

You are currently located in Southern Unpaid Lobby region. . You have been traveling north.. The Fare Gates unpaid side is about 5 feet to your 12 o'clock in the northwest direction. . Head towards Fare Gates unpaid side. Select next instructions button.

Next Instruction
Prior Instruction
End Journey

# Demonstration


Fare Gates
Escalator
Valenti Street Entrance
Green Line Towards Lechmere Platform


Carrier
11:24 PM

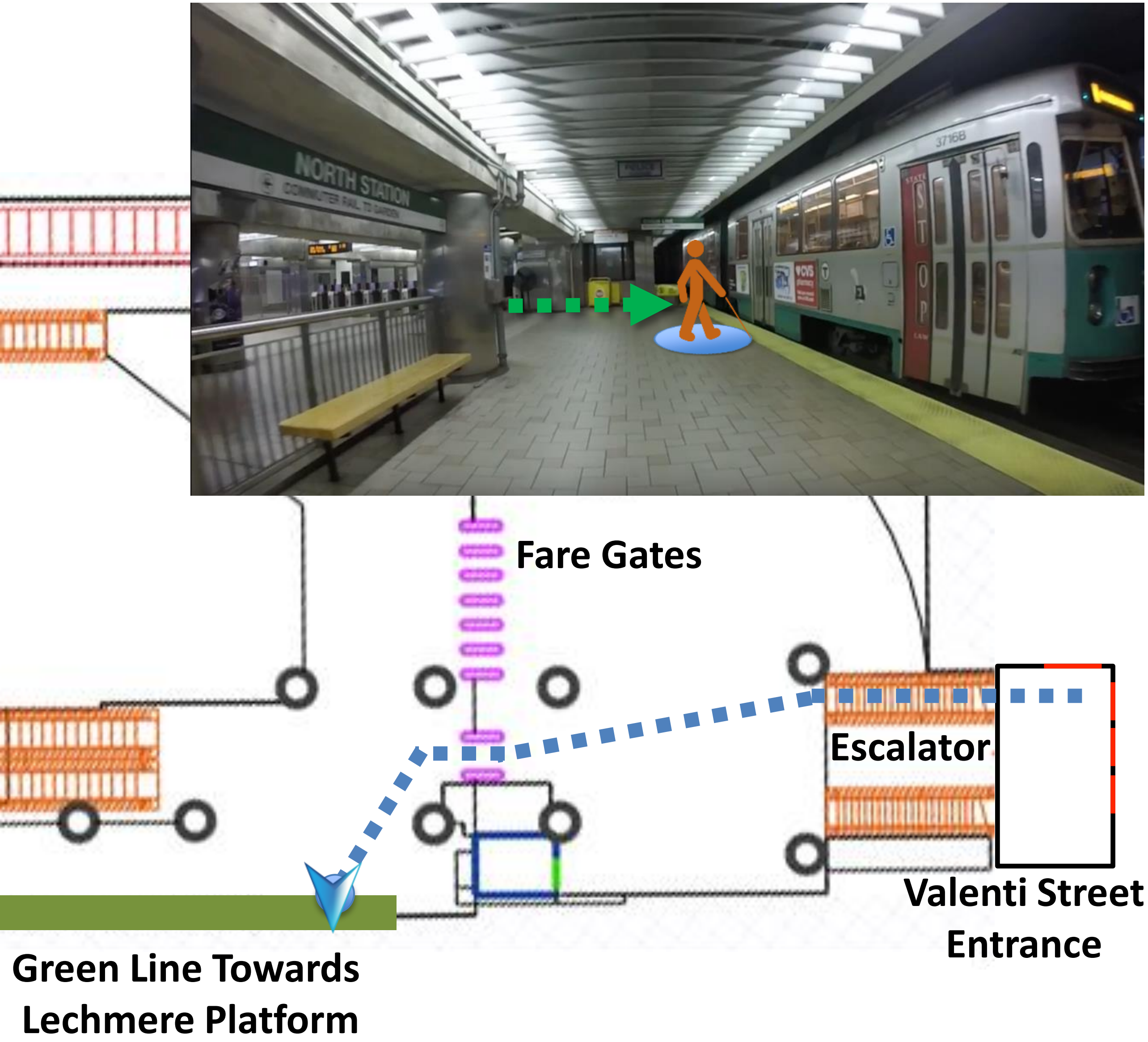
Instructions to Green Platform to Lechmere

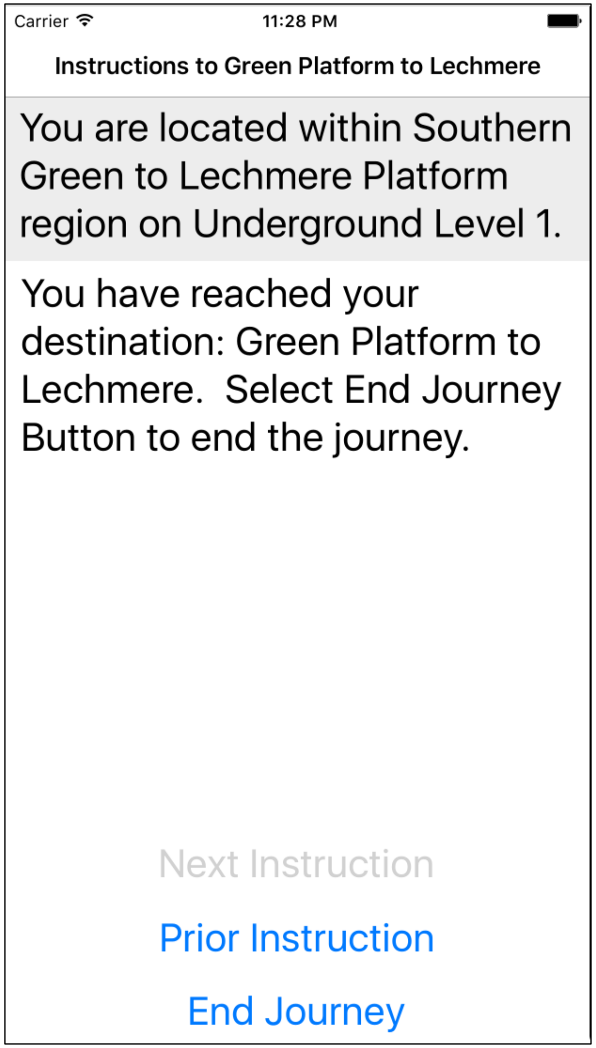
You are located within Southern Paid Lobby region on Underground Level 1.

Go through Fare Gates, With the Fare Gates to your back, There is Green Platform to Lechmere to your 10 o'clock direction, Walk across to the Green Platform to Lechmere to your 10 o'clock direction, heading southwest, 30 feet away, You will face the track. Select next instructions button.

Next Instruction
Prior Instruction
End Journey

# Demonstration


NORTH STATION
COMMUTER RAIL TO GARDEN
STOP
Fare Gates
Escalator
Valenti Street Entrance
Green Line Towards Lechmere Platform


Carrier
11:28 PM

Instructions to Green Platform to Lechmere

You are located within Southern Green to Lechmere Platform region on Underground Level 1.

You have reached your destination: Green Platform to Lechmere. Select End Journey Button to end the journey.

Next Instruction
Prior Instruction
End Journey

# Outline

- Introduction
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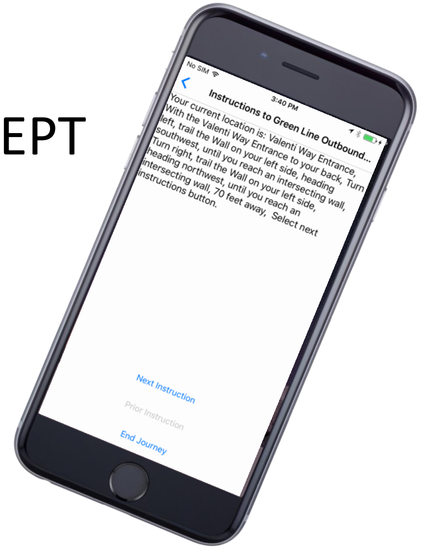
- **System Overview**
- Usability Study
- Conclusion

PERCEPT

# Components

- **PERCEPT Space**
  - PERCEPT tags deployed in venue
  - Digital representation of venue

- **PERCEPT Navigation Instructions**
  - Wayfinding instructions generated through PERCEPT navigation instruction generation algorithm
    - Uses digital map
    - Uses O&M rule book

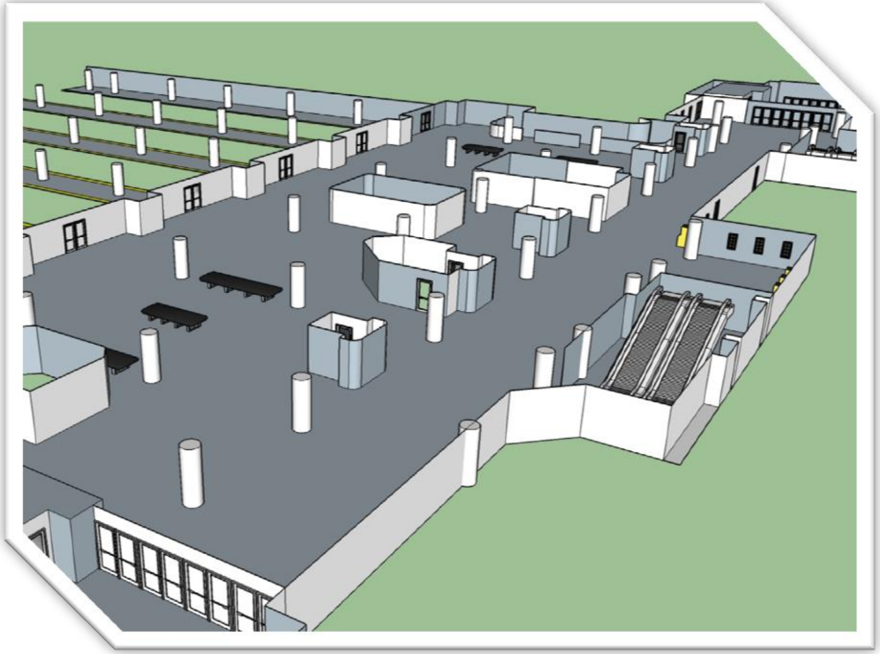

No SIM
3:40 PM
Instructions to Green Line Outbound...
Next Instruction
Prior Instruction
End Journey

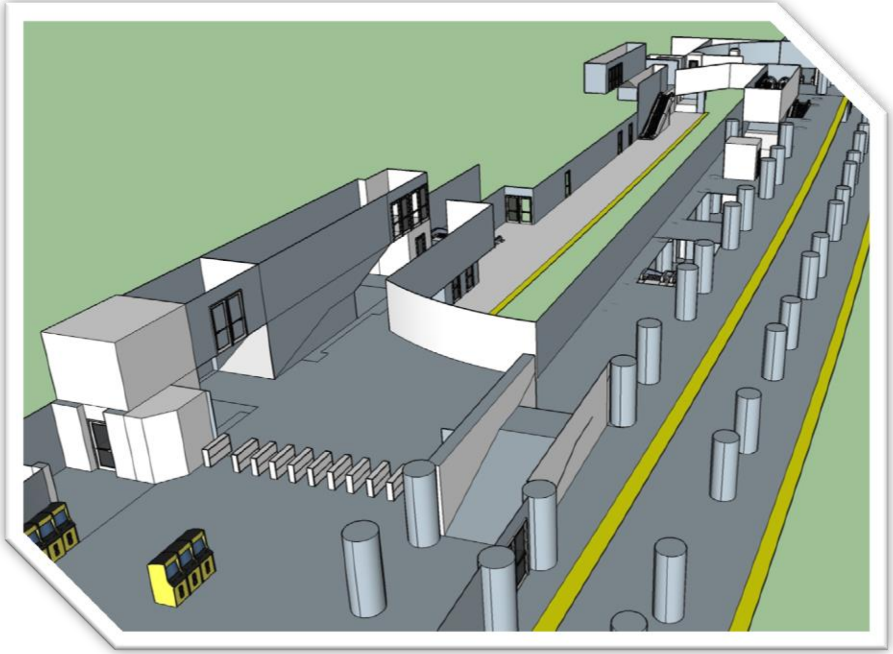
Your current location is: Valenti Way Entrance, With the Valenti Way Entrance to your back, Turn left, trail the Wall on your left side, heading southwest, until you reach an intersecting wall, Turn right, trail the Wall on your left side, heading northwest, until you reach an intersecting wall, 70 feet away, Select next instructions button.

- **PERCEPT Smartphone application**
    - No Internet required when providing navigation instructions
    - Accessible vision free user interface

# North Station Deployment

Encompasses 2 Unique Environments





TD GARDEN

**Purple**

Commuter Rail

Ground Floor

**Green**

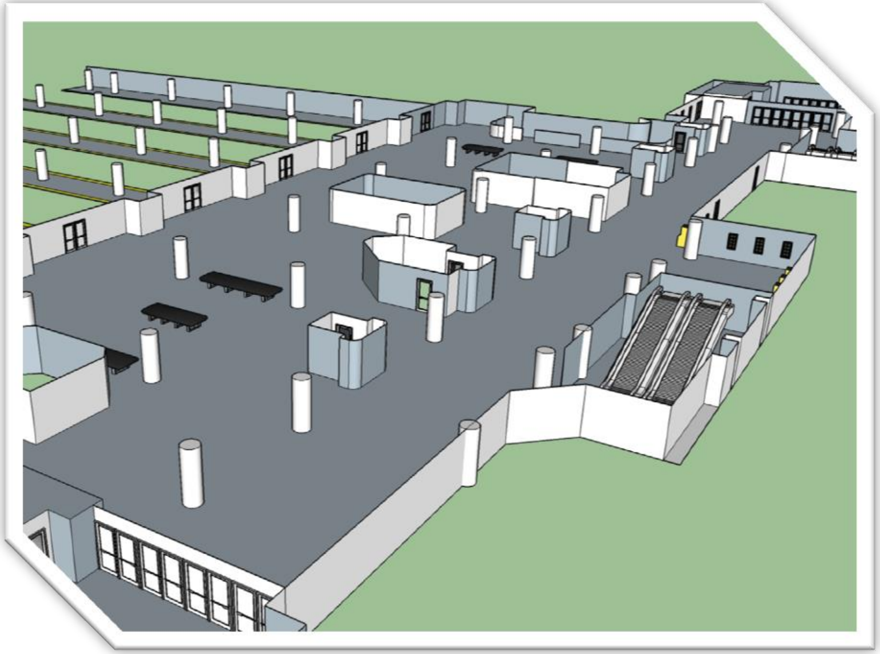
**Orange**

Subway

3 Floors

# North Station Commuter Rail

## Encompasses 2 Unique Environments



**Purple**

Commuter Rail

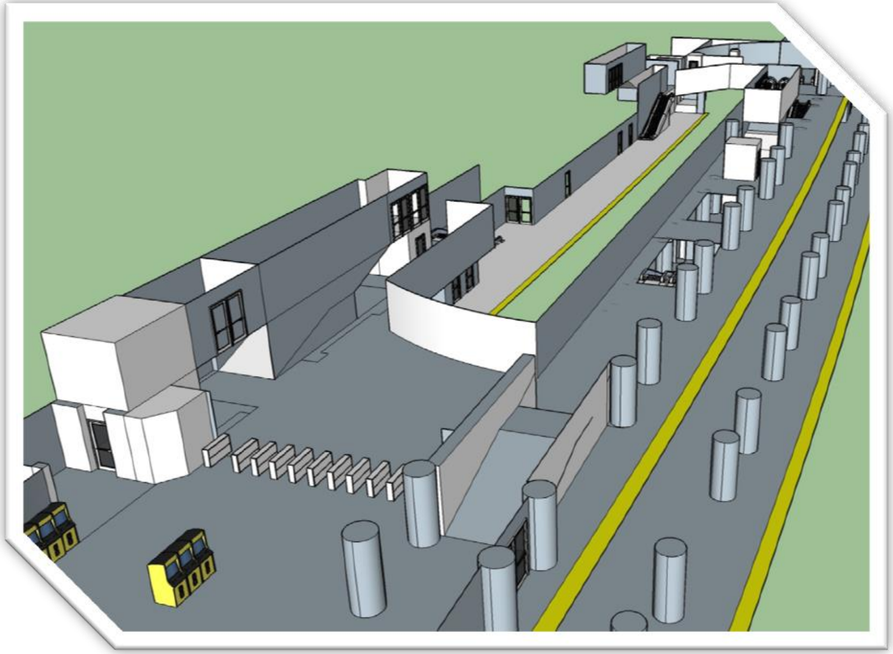
Ground Floor

- Houses both the Commuter Rail and Amtrak Services located on the ground floor within the TD Garden
- This floor also is the location for
  - TD Garden Box Office
  - Fast Food restaurants
  - Convenience store,
  - Restroom facilities,
  - Service Desk for Amtrak and Commuter rail
  - ATM

# North Station Subway

## Encompasses 2 Unique Environments

- Houses Green and Orange subway lines
- Composed of three floors
  - Street Level Access
    - North & South Entrances
  - Underground Floor 1
    - Fare Machines
    - Fare Gateways
    - Information Desk
    - Outbound Green Line
  - Underground Floor 2
    - Inbound Green Line
    - Outbound Orange Line
    - Inbound Orange Line



**Green**

**Orange**

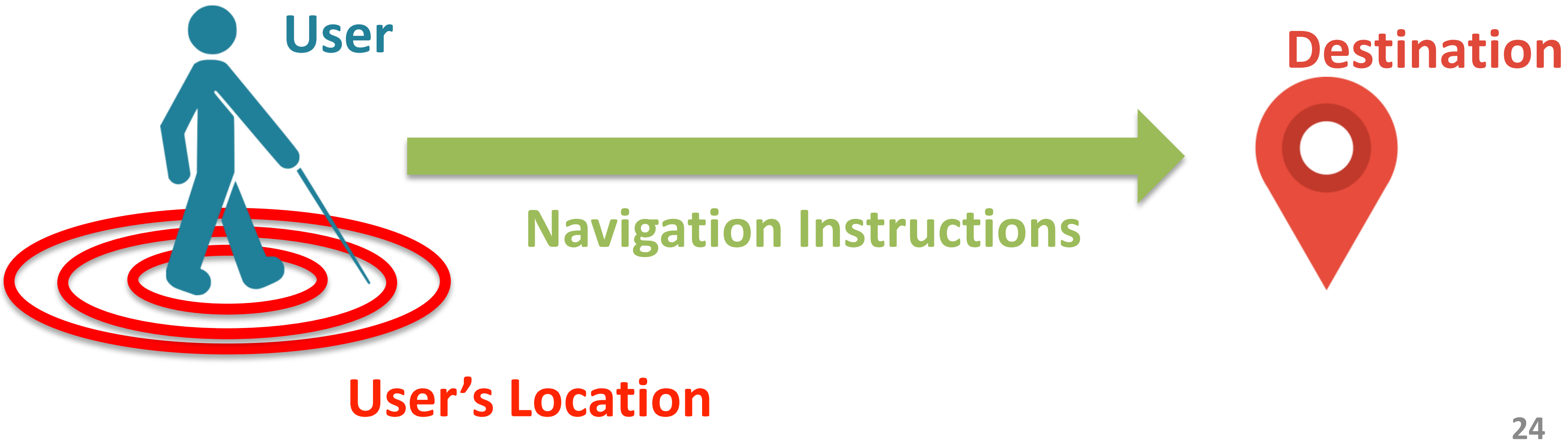
Subway

3 Floors

# PERCEPT Tag Overview

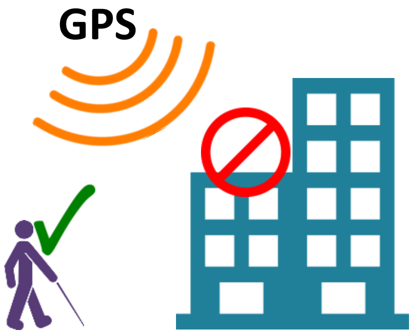
- PERCEPT Tag is a Bluetooth tag, also known as an iBeacon
- Tag is needed for navigation instructions
  - In order to provide instructions to a destination, we need to know where the user is located

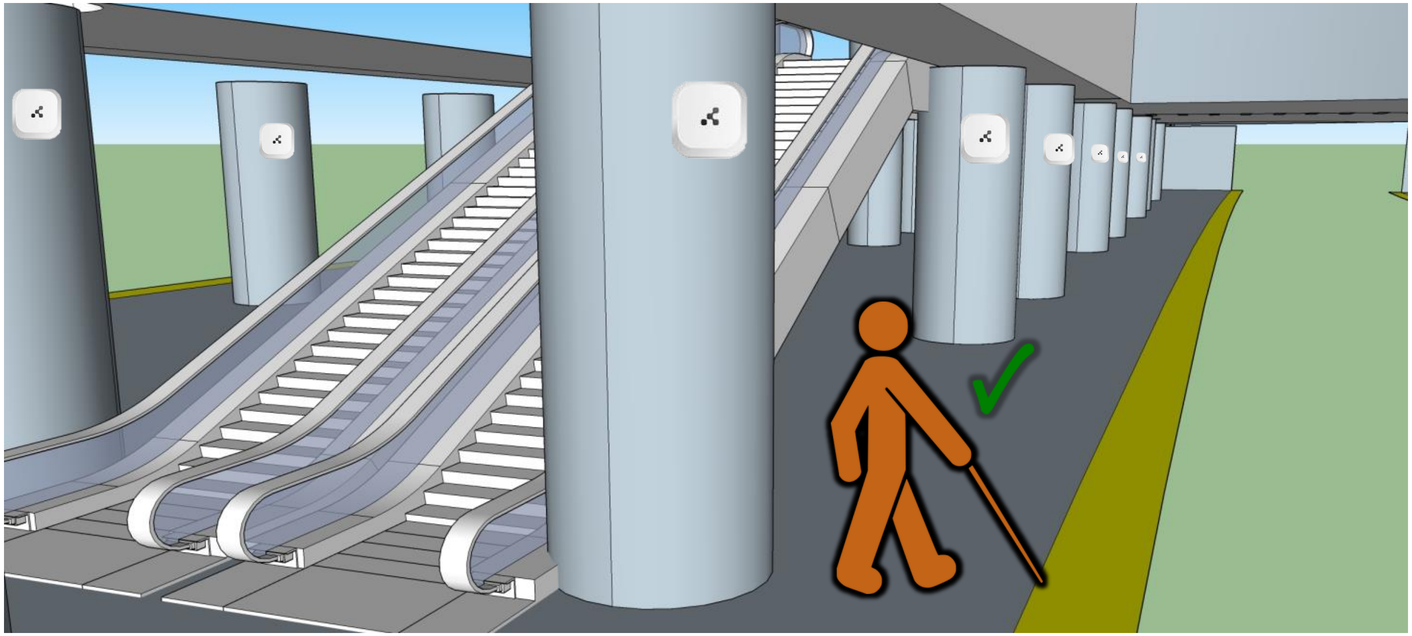
Bluetooth®


User
Destination
Navigation Instructions
User's Location

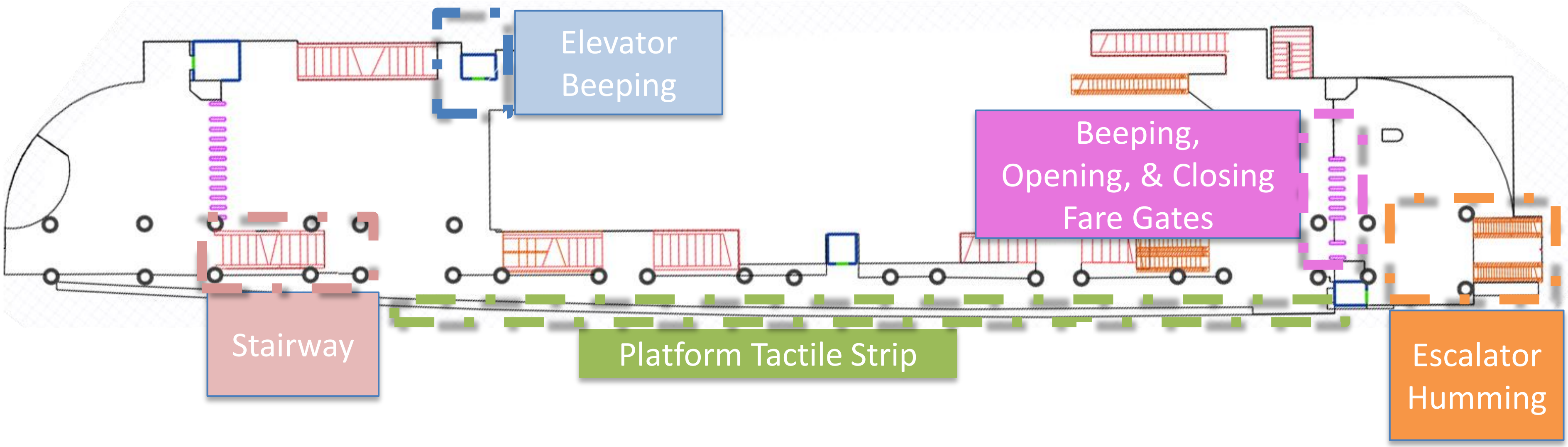
# PERCEPT Tag Overview

- Outdoor navigation we are accustomed to GPS
  - GPS does not work indoors
- PERCEPT tags provides GPS like capabilities indoors
- Tags are mounted up high on ceilings and walls





# PERCEPT Space

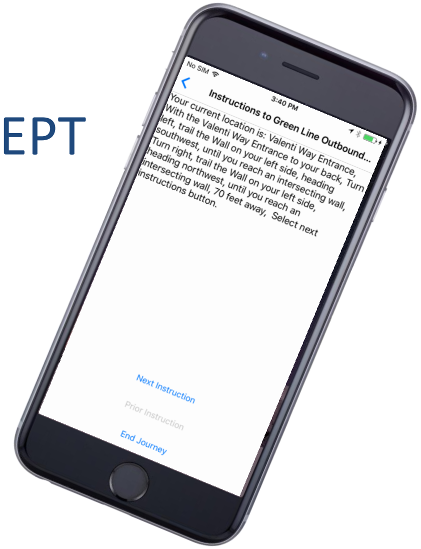

Elevator Beeping
Beeping, Opening, & Closing Fare Gates
Stairway
Platform Tactile Strip
Escalator Humming

- Digital representation of the venue
  - Contains the sensory roadmap for the venue
- Digital rulebook that adheres Orientation and Mobility best practices
- PERCEPT looks at the digital representation and refers to the rulebook to generate navigation instructions

# Components

- **PERCEPT Space**
  - – PERCEPT tags deployed in venue
  - – Digital representation of venue

- **PERCEPT Navigation Instructions**
  - – Wayfinding instructions generated through PERCEPT navigation instruction generation algorithm
    - Uses digital map
    - Uses O&M rule book



**Instructions to Green Line Outbound...**

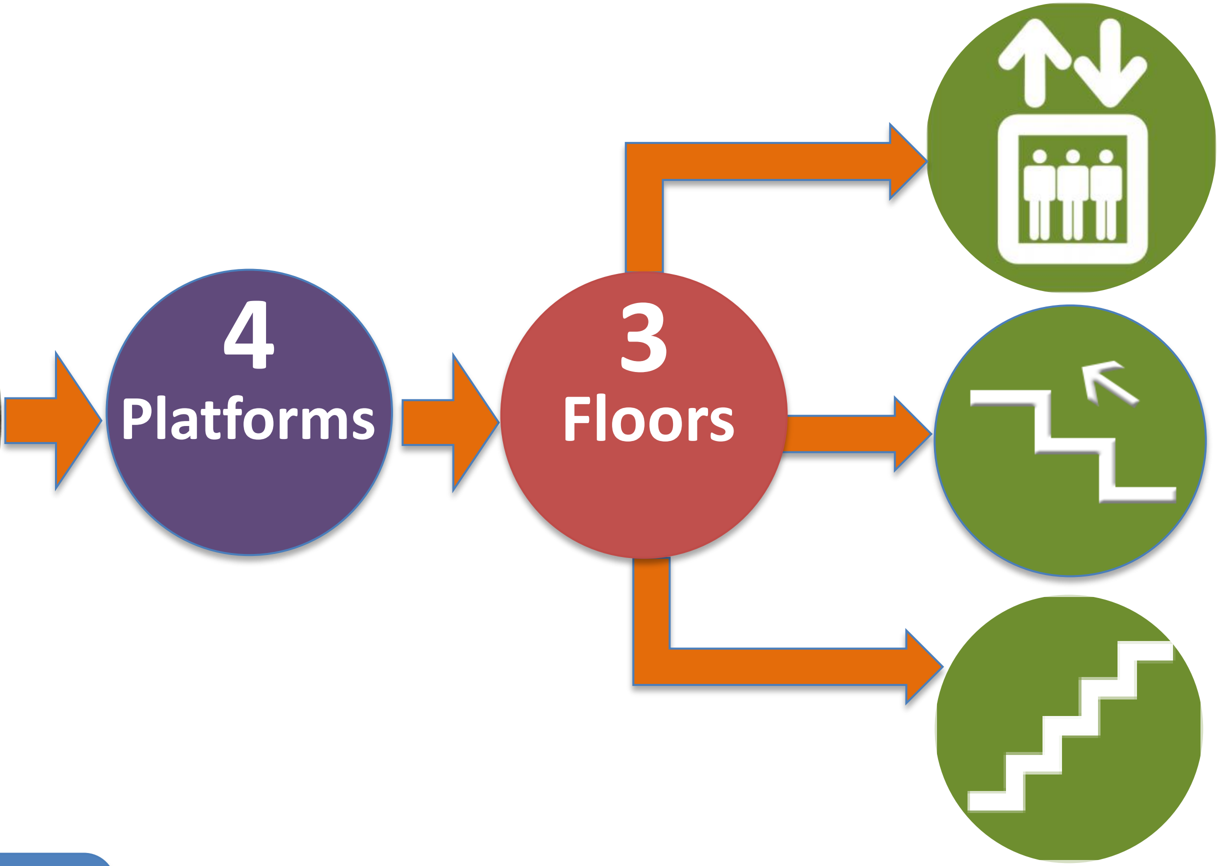
Your current location is: Valenti Way Entrance, With the Valenti Way Entrance to your back, Turn left, trail the Wall on your left side, heading southwest, until you reach an intersecting wall, Turn right, trail the Wall on your left side, heading northwest, until you reach an intersecting wall, 70 feet away, Select next instructions button.

- **PERCEPT Smartphone application**
  - No Internet required when providing navigation instructions
  - Accessible vision free user interface

# Navigation Instructions

North Station

GREEN LINE
INBOUND
TO PARK ST
3676



4 Platforms

3 Floors

Over

**2,800**

detailed instructions generated

in 5 minutes

# Navigation Instructions

- Automated instruction generation provide a cost-effective and scalable means to provide detailed navigation instructions
- O&M specialist is not manually crafting each PERCEPT instructions
- This algorithm is continually being improved

# Components

- **PERCEPT Space**
  - PERCEPT tags deployed in environment
  - Digital representation of environment

- **PERCEPT Navigation Instructions**
  - Wayfinding instructions generated through PERCEPT navigation instruction generation algorithm
    - Uses digital map
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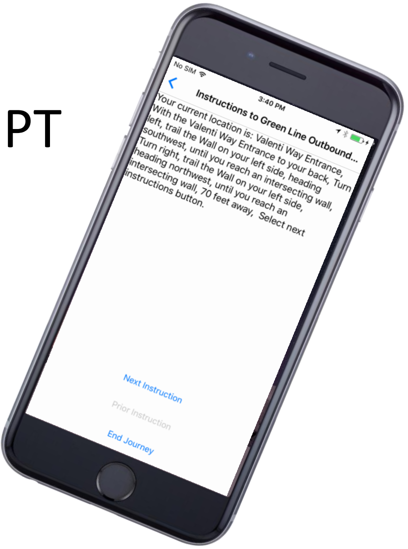
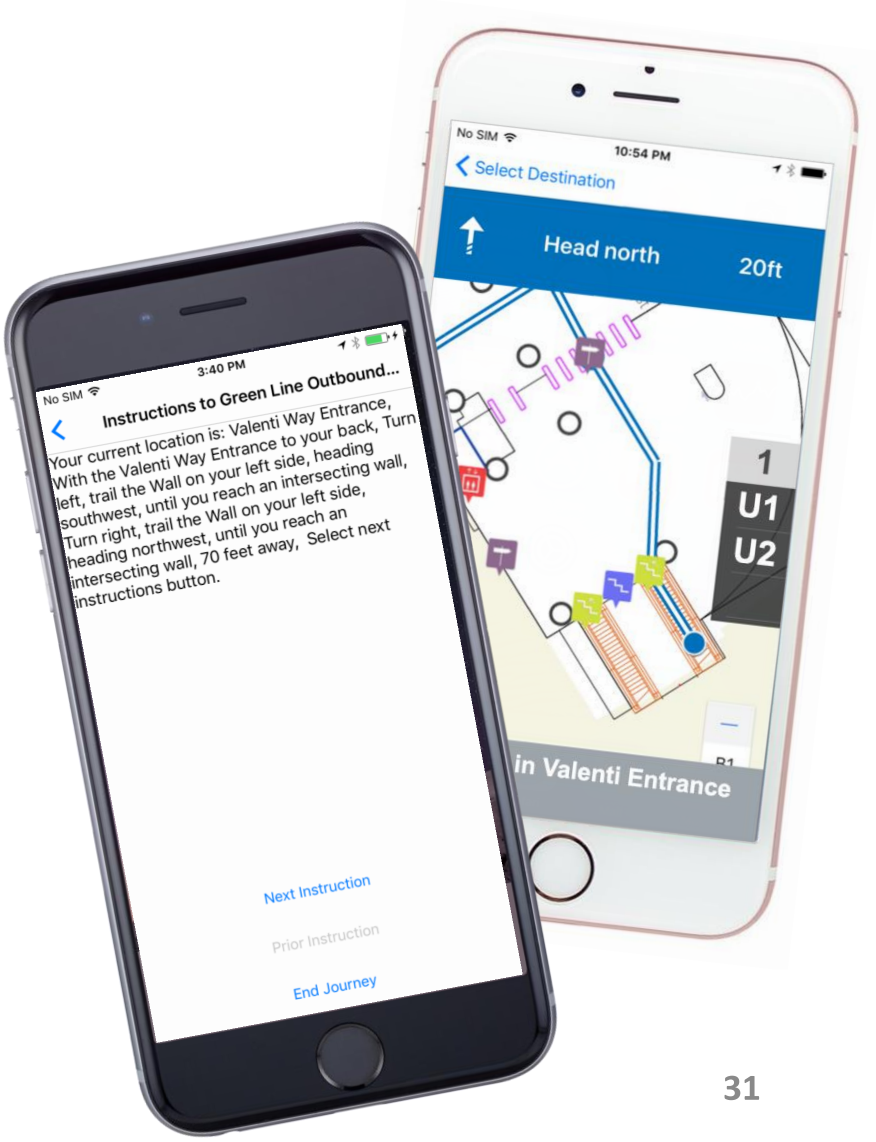

No SIM
3:40 PM
Instructions to Green Line Outbound...
Next Instruction
Prior Instruction
End Journey

Your current location is: Valenti Way Entrance, With the Valenti Way Entrance to your back, Turn left, trail the Wall on your left side, heading southwest, until you reach an intersecting wall, Turn right, trail the Wall on your left side, heading northwest, until you reach an intersecting wall, 70 feet away, Select next instructions button.

- **PERCEPT Smartphone application**
    - No Internet required when providing navigation instructions
    - Accessible vision free user interface

# PERCEPT Application

- No Internet required
- User friendly design
- Accessible “Vision Free” interface for blind and visually impaired
  - Integrated with Voiceover and Large Font accessible services on iPhone
- Accessible visual user interface
  - In Development
- Available on iOS and Android platforms



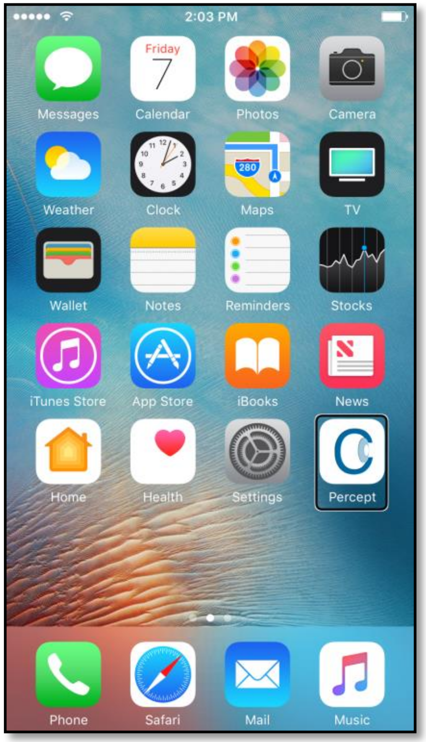
No SIM 3:40 PM

Instructions to Green Line Outbound...

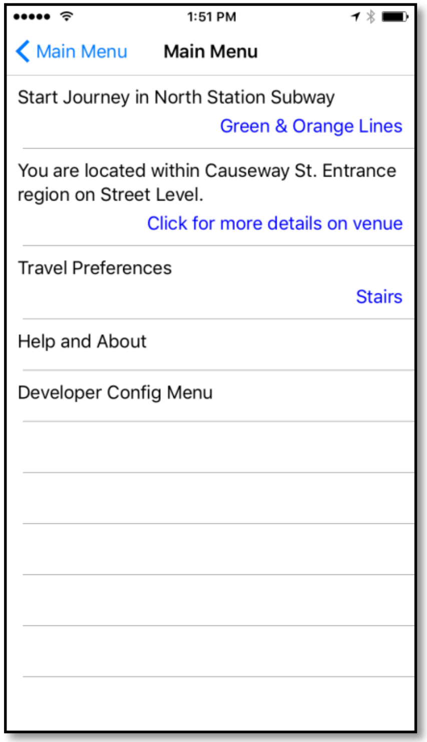
Your current location is: Valenti Way Entrance, With the Valenti Way Entrance to your back, Turn left, trail the Wall on your left side, heading southwest, until you reach an intersecting wall, Turn right, trail the Wall on your left side, heading northwest, until you reach an intersecting wall, 70 feet away, Select next instructions button.

Next Instruction
Prior Instruction
End Journey
No SIM
10:54 PM
Select Destination
Head north
20ft
1
U1
U2
B1
in Valenti Entrance

# PERCEPT Application Flow


2:03 PM
Messages
Friday 7
Calendar
Photos
Camera
Weather
Clock
Maps
TV
Wallet
Notes
Reminders
Stocks
iTunes Store
App Store
iBooks
News
Home
Health
Settings
Percept
Phone
Safari
Mail
Music

Open PERCEPT Application


1:51 PM
Main Menu

**Main Menu**

Start Journey in North Station Subway
Green & Orange Lines

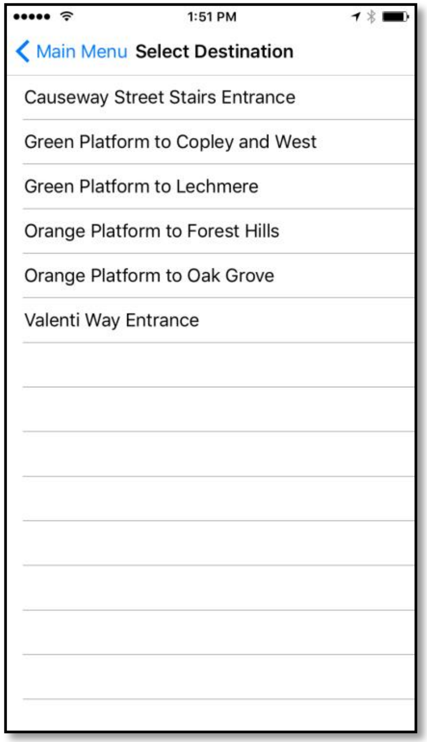
You are located within Causeway St. Entrance region on Street Level.
Click for more details on venue

Travel Preferences
Stairs

Help and About

Developer Config Menu

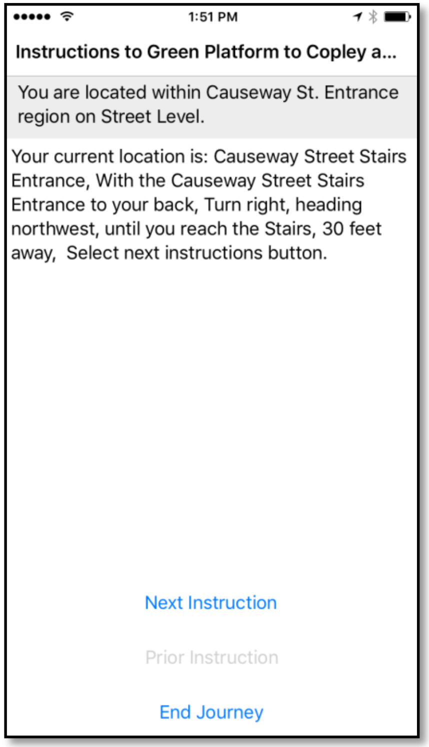
Select ‘Start Journey’ From Main Menu


1:51 PM
Main Menu

**Select Destination**

Causeway Street Stairs Entrance
Green Platform to Copley and West
Green Platform to Lechmere
Orange Platform to Forest Hills
Orange Platform to Oak Grove
Valenti Way Entrance

Select Your Desired Destination


1:51 PM

**Instructions to Green Platform to Copley a...**

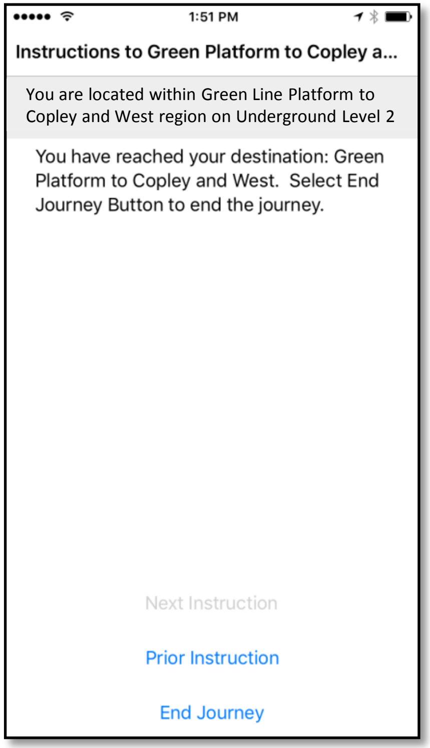
You are located within Causeway St. Entrance region on Street Level.

Your current location is: Causeway Street Stairs Entrance, With the Causeway Street Stairs Entrance to your back, Turn right, heading northwest, until you reach the Stairs, 30 feet away,  Select next instructions button.

Next Instruction
Prior Instruction
End Journey

Receive Detailed Instructions to Destination

# PERCEPT Application Flow


1:51 PM
Instructions to Green Platform to Copley a...
Next Instruction
Prior Instruction
End Journey

You are located within Green Line Platform to Copley and West region on Underground Level 2

You have reached your destination: Green Platform to Copley and West. Select End Journey Button to end the journey.

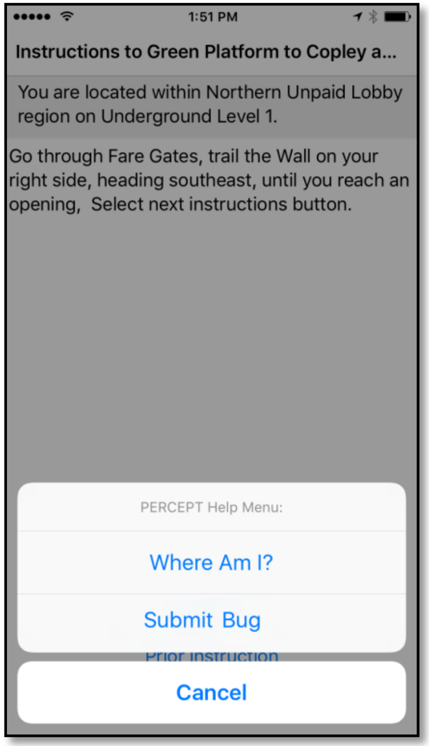
Reach Destination

? ? ?

**Disoriented**

**Or Lost**

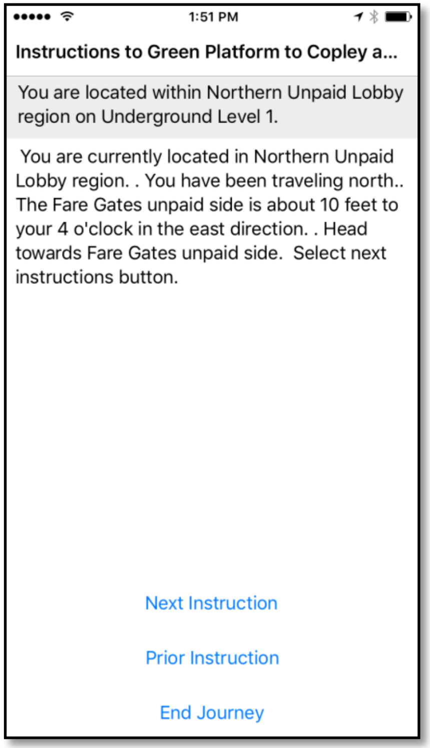
? ?


1:51 PM
Instructions to Green Platform to Copley a...
PERCEPT Help Menu:
Where Am I?
Submit Bug
Prior Instruction
Cancel

You are located within Northern Unpaid Lobby region on Underground Level 1.

Go through Fare Gates, trail the Wall on your right side, heading southeast, until you reach an opening, Select next instructions button.

Shake Device
To Open
Help Menu


1:51 PM
Instructions to Green Platform to Copley a...
Next Instruction
Prior Instruction
End Journey

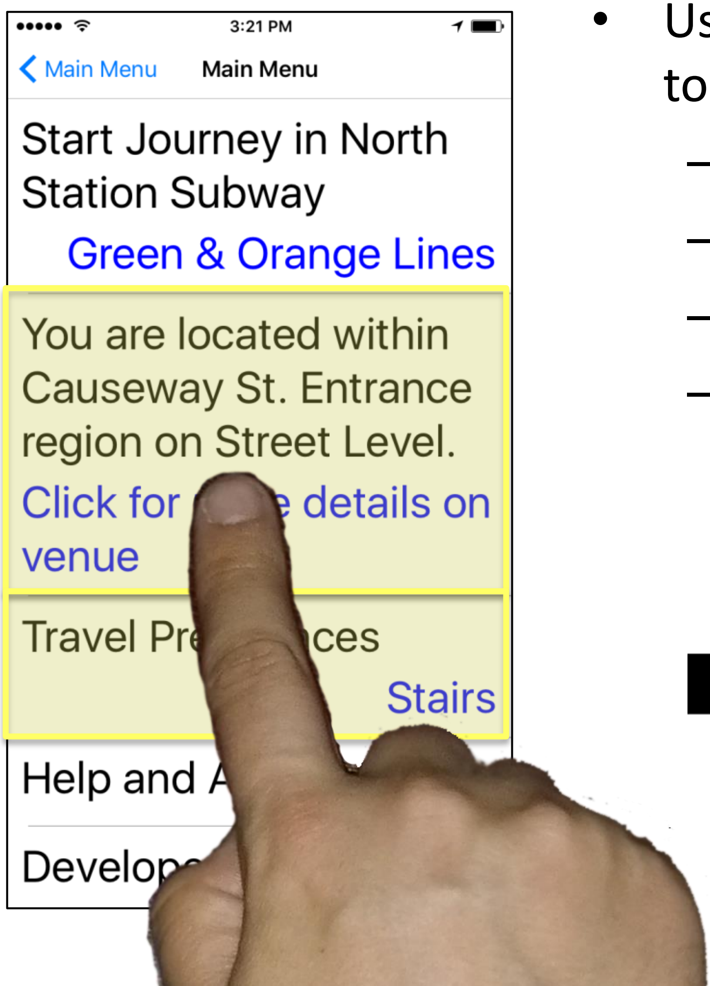
You are located within Northern Unpaid Lobby region on Underground Level 1.

You are currently located in Northern Unpaid Lobby region. . You have been traveling north.. The Fare Gates unpaid side is about 10 feet to your 4 o'clock in the east direction. . Head towards Fare Gates unpaid side. Select next instructions button.

Select
'Where Am I?'

# Vision Free User Interface

Voiceover in iOS allow for Vision Free Use of Smart Device



3:21 PM

Start Journey in North Station Subway
Green & Orange Lines

You are located within Causeway St. Entrance region on Street Level.
Click for e details on venue

Travel Pr ces
Stairs

Help and A

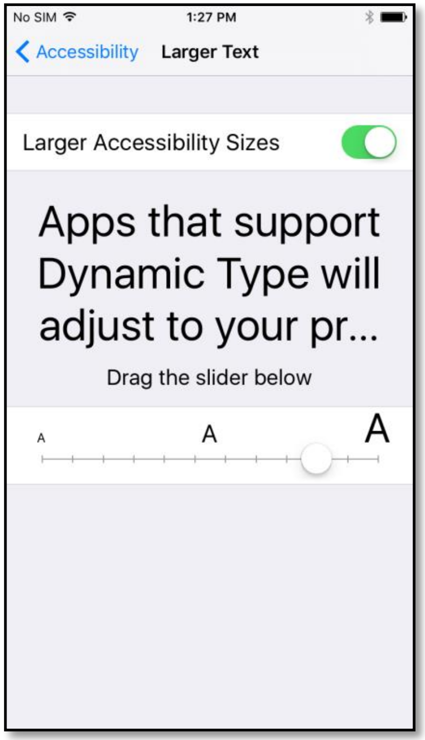
Develop

- User navigates the application by performing touch gestures on the screen
  - **Touch:** Item touched is read to user
  - **Swipe Right or Down**: Select Next Item
  - **Swipe Left or Up**: Select Prior Item
  - **Double Tap:** '*Clicks*' selected item

You are located within Causeway Street Entrance ...

# Large Font Integration

- User sets a preferred font size within their devices settings.
- This preference is inherited into PERCEPT.



No SIM
1:27 PM
Accessibility
Larger Text

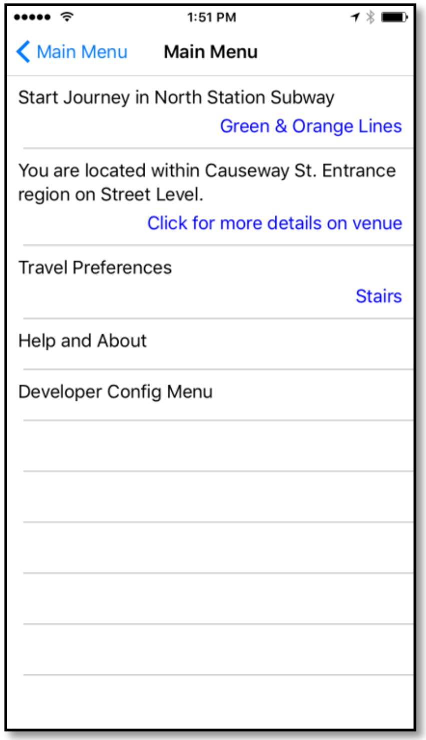
Larger Accessibility Sizes

Apps that support Dynamic Type will adjust to your pr...

Drag the slider below

A
A
A

**Global Font Size Setting**



1:51 PM
Main Menu
Main Menu

Start Journey in North Station Subway
Green & Orange Lines

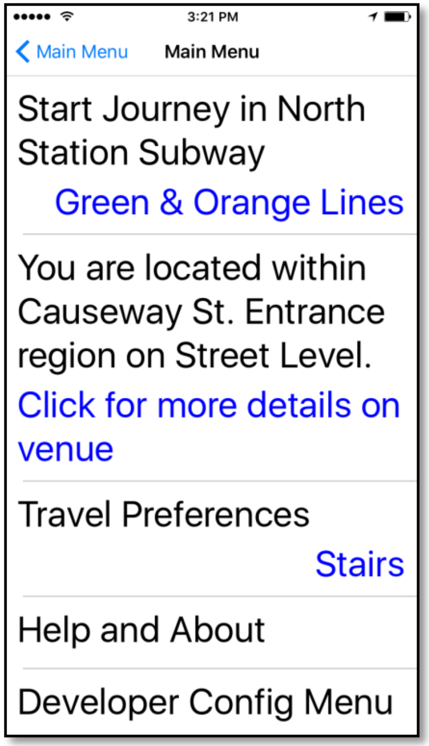
You are located within Causeway St. Entrance region on Street Level.
Click for more details on venue

Travel Preferences
Stairs

Help and About

Developer Config Menu

**Default Font Size**



3:21 PM
Main Menu
Main Menu

Start Journey in North Station Subway
Green & Orange Lines

You are located within Causeway St. Entrance region on Street Level.
Click for more details on venue

Travel Preferences
Stairs

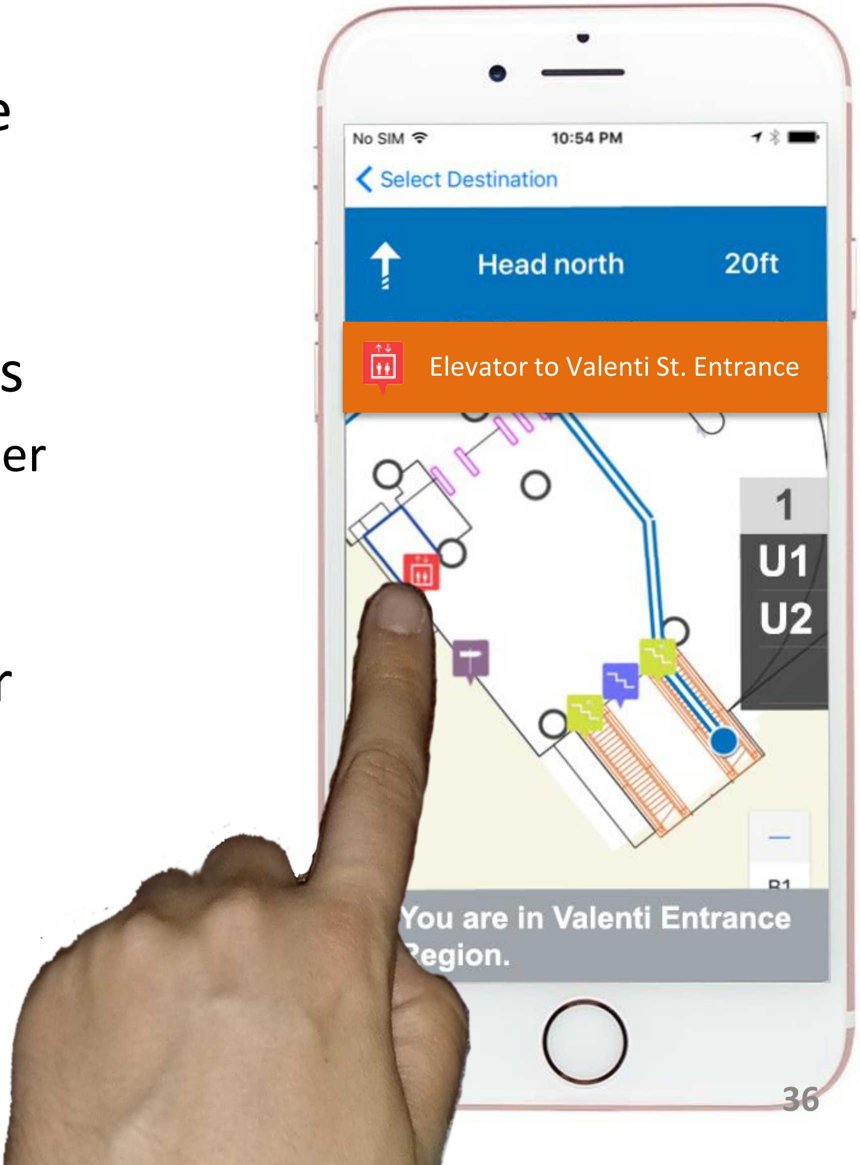
Help and About

Developer Config Menu

**Preferred Font Size**

# PERCEPT Visual UI

- Provides a visual pathway to the selected destination
- Indicates surrounding landmarks
  - User can select landmark for further details
- User can select a preferred floor traversal preference.
  - Elevator, Stairs, Escalator, …



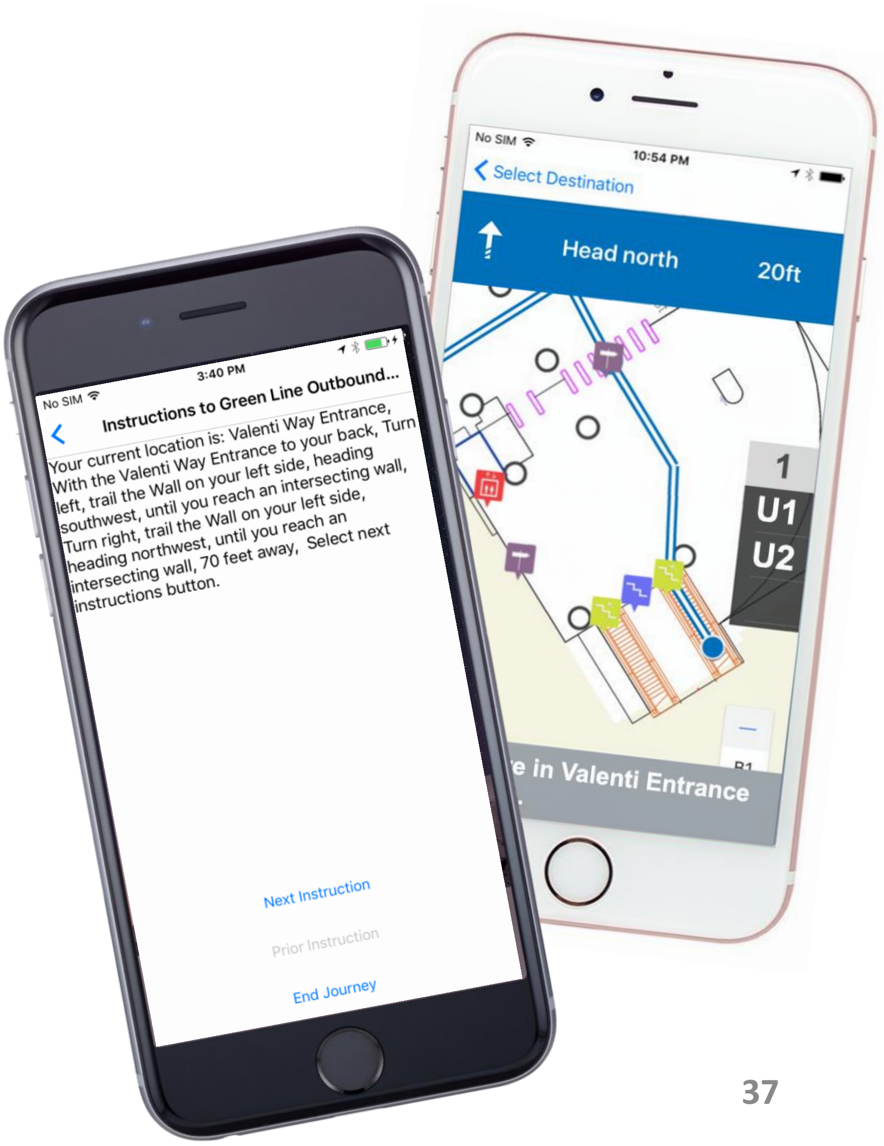
Head north 20ft

Elevator to Valenti St. Entrance

You are in Valenti Entrance Region.

# Pre Journey Navigation

- PERCEPT provides pre-journey learning options
- Select destination and starting point in PERCEPT app
- Go through station instructions or visual path step by step
- Explore station from comfort of your own home


No SIM
10:54 PM
Select Destination
Head north
20ft
1
U1
U2
P1
e in Valenti Entrance
No SIM
3:40 PM
Instructions to Green Line Outbound...
Next Instruction
Prior Instruction
End Journey

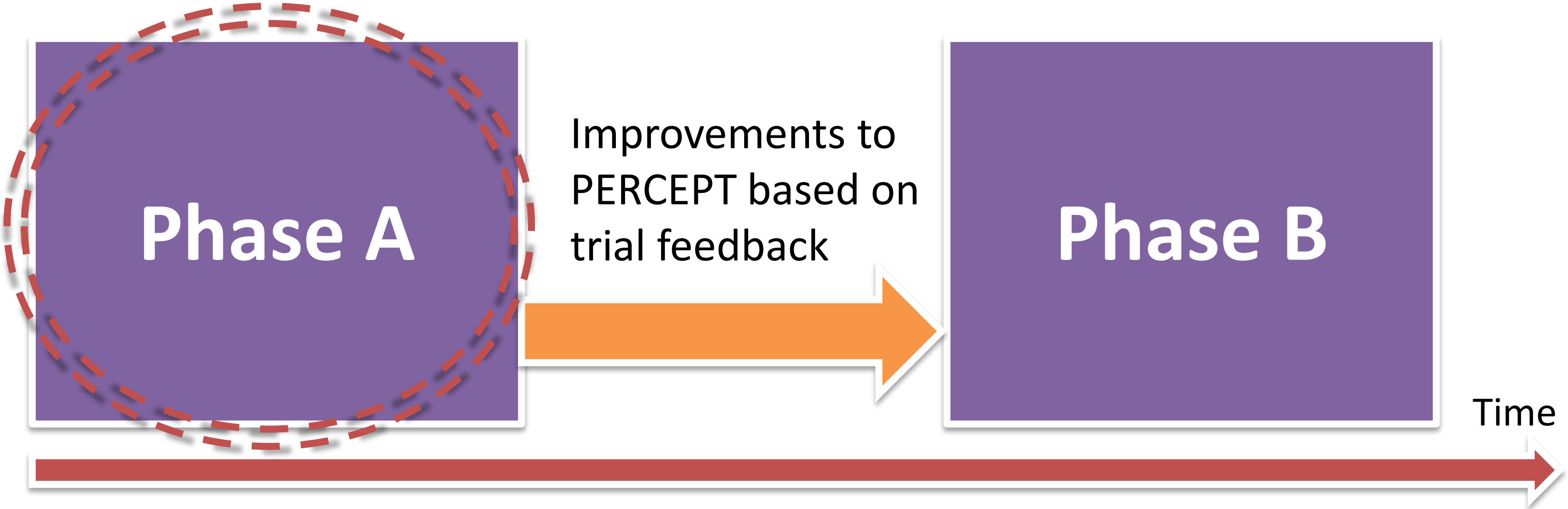
Your current location is: Valenti Way Entrance, With the Valenti Way Entrance to your back, Turn left, trail the Wall on your left side, heading southwest, until you reach an intersecting wall, Turn right, trail the Wall on your left side, heading northwest, until you reach an intersecting wall, 70 feet away, Select next instructions button.

# Outline

- Introduction
- Demonstration
- System Overview
- **Usability Study**
- Conclusion

# Usability Study Overview

Two Phases



Improvements to PERCEPT based on trial feedback

- Blind or visually impaired subject use PERCEPT
- Returning participants from Phase A and new participants use PERCEPT

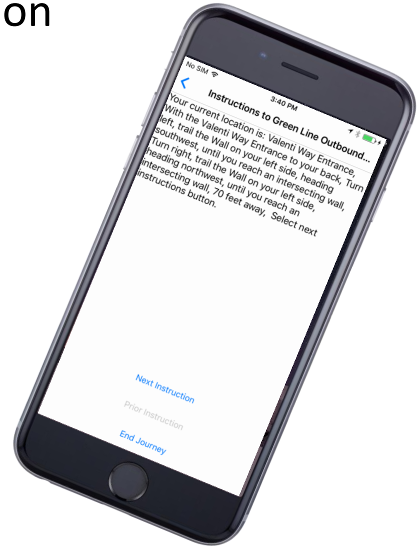
# Phase A Trials

Blind or Visually
Impaired Participants

Navigate Throughout
North Station

Using

PERCEPT



No SIM
3:40 PM

**Instructions to Green Line Outbound...**

Your current location is: Valenti Way Entrance, With the Valenti Way Entrance to your back, Turn left, trail the Wall on your left side, heading southwest, until you reach an intersecting wall, Turn right, trail the Wall on your left side, heading northwest, until you reach an intersecting wall, 70 feet away, Select next instructions button.

Next Instruction
Prior Instruction
End Journey

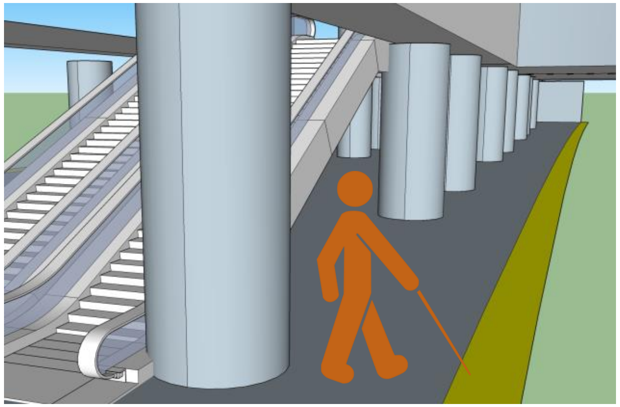
# Trial Composition

## Hands-on Orientation

- Sit-down & on-site

## PERCEPT Trial

- 4 Destinations
- Entering and exiting station from different entrances and platforms



## Post Trial Questionnaire

- Questionnaire to obtain:
  - Subjects feedback and experience
  - Qualitative evaluation of PERCEPT

# PERCEPT Trial

- PERCEPT trial is composed of four tasks
- Subject is asked to complete these tasks while only relying on their mobility skills and PERCEPT App
- Instructor is no longer able to answer any questions or assist subject during the trial
- Trial ends either when all tasks are complete or subject decides to stop

# Post-Trial Questionnaire

Subjects were asked to answer the following statements with a 7-point scale. **1**(strongly disagree) to **7**(strongly agree)

**a) Easy to learn how to use the system**

**b) Easy to use the system**

**c) Trial design was easy to complete**

**d) Easy to use User Interface**

**e) System provided sufficient re-orientation information when lost**

**f) I am confident I will reach destination using the system**

Subjects were asked to give their impression on the following:

**1) Likes/dislikes of the system?**
**2) Name the most difficult part of using the system**
**3) Name the most difficult part of the trial**
**4) Level of confidence in self – How confident were you when the trial started, that you could accomplish the task successfully?**
**5) Are there some improvements you'd suggest we make to the system?**
**6) Based on your experience using PERCEPT if you were to come to an PERCEPT enabled subway station in the future, would you use it?**

# PERCEPT Usability Study Results

- All participants were able to complete the 4 navigation tasks
- All participants thought PERCEPT was beneficial to them and said they would use it if available

Subjects were asked to answer the following statements with a 7-point scale. **1**(strongly disagree) to **7**(strongly agree)

*North Station scores below are averaged*

| | |
|---|---|
| **a) Easy to learn how to use the system** | **7** |
| **b) Easy to use the system** | **7** |
| **c) Trial design was easy to complete** | **6** |
| **d) Easy to use User Interface** | **6.5** |
| **e) System provided sufficient re-orientation information when lost** | **6** |
| **f) I am confident I will reach destination using the system** | **6.5** |

# Outline

- Introduction
- Demonstration
- System Overview
- Usability Study
- **Conclusion**

# Conclusions

- Conducted over 60 trials with blind and visually impaired participants in buildings and subway stations
- Trials demonstrated that PERCEPT is easy to learn and use
- All participants said they would use PERCEPT if available in transit venue
- Pre-journey learning option

# Q & A

- PERCEPT is not exclusive to blind and visually impaired
- There is significant potential to aid others when it comes to wayfinding in a transit setting
- We are actively researching new methods to make PERCEPT inclusive and accessible to all
- We seek feedback from those present for how their patrons, clients, or they themselves may benefit from PERCEPT

# Thank You

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5 Labs
Elevating Human Potential
Through Technology

- http://5g.ecs.umass.edu/

PERCEPT

- http://www.perceptwayfinding.com/